TERRA

THE NATURAL HISTORY
MUSEUM OF
LOS ANGELES COUNTY

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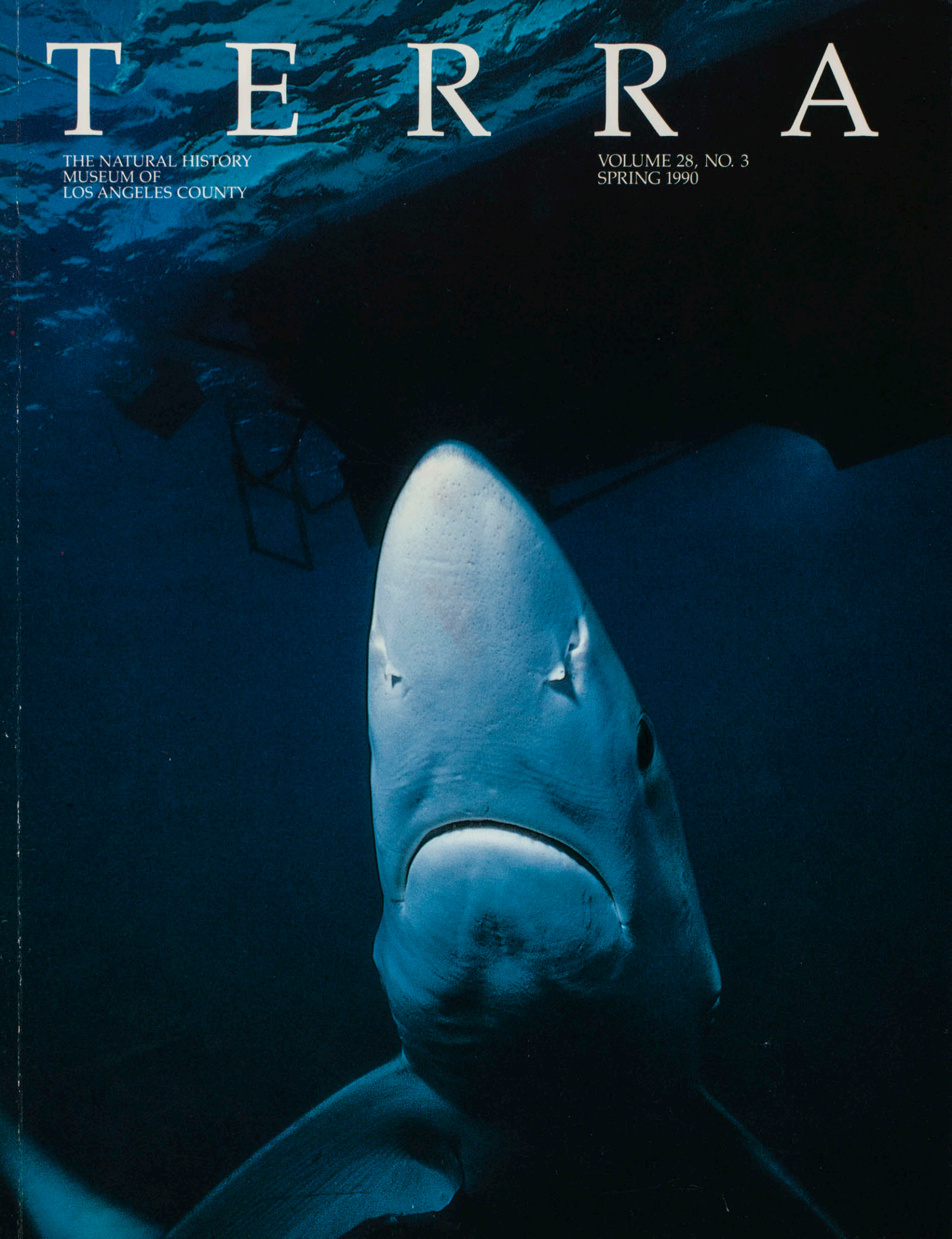

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TERRA

THE MEMBERS' MAGAZINE
OF THE
NATURAL HISTORY MUSEUM
OF LOS ANGELES COUNTY

VOLUME 28, NO. 3
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MAY 1990

COVER:
The blue shark *(Prionace glauca)* has been recorded as the shark long-distance champion swimmer: a blue shark tagged off New York State was recovered off the coast of Brazil 3,740 miles away. See page 8 for the more about sharks and the museum's exhibition **Sharks! Fact and Fantasy**. Photograph by David McCray.

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FROM THE DIRECTOR

THANKS TO OUR MEMBERS, THE KRESGE CHALLENGE GRANT HAS BEEN MET. I am delighted to announce that with strong support from our members, we have successfully met the Kresge Foundation's $750,000 challenge. Over $2.34 million was raised to complete the Ralph W. Schreiber Hall of Birds and Times Mirror Hall of Native American Cultures and to strengthen the museum's services to members and visitors.

You made the difference! Each of you who responded generously when telephoned about the challenge should take pride in the gift you are giving our community. As you fulfill your pledges, these two remarkable halls will be taking shape. The first benefit accrues this fall when all visitors, from excited children to avid birders to museum members, will be able to visit the Schreiber Bird Hall.

Thank you for your belief in the museum. Your willingness to stretch beyond your annual membership gift encourages our commitment to bring the best of natural science and history to southern California.

The work of the museum has global importance as well. In January I traveled to Cairo to address a meeting of the World Conference on Preparing for Climate Change. At this meeting, convened by the Climate Institute, the United Nations Environment Programme, and the government of Egypt, I co-chaired a panel discussion of new research developments in global climate change.

Approximately 400 international participants examined the implications of climate change for all seven continents. As the first world climate meeting to be held in a developing country, the Cairo conference focused on strategies for such countries as Egypt, Bangladesh, Pakistan, India, China, Indonesia, and several African nations. Unlike previous international climate meetings, which have tended to emphasize government-to-government discussions, this conference emphasized the role of non-governmental organizations and the private sector. One of the hoped-for outgrowths of the conference will be the seeking of practical means to ensure that developing countries receive necessary technical assistance and financing to prepare for global warming, rising sea levels, and other climate changes brought on by human activities.

Craig C. Black
Director

GRANTS

NATURAL HISTORY MUSEUM PARTICIPATES IN MUSEUM ASSESSMENT PROGRAM. The William S. Hart Museum, a satellite facility of the Natural History Museum, recently participated in MAP II, a program funded by the federal government through the Institute of Museum Services (IMS) and administered by the American Association of Museums (AAM). The museum previously received a MAP grant in 1986, and the report generated from that consultation has been used as an important planning document for the museum. The concerns expressed have been addressed and are in many ways responsible for the Natural History Museum's renewed involvement at the Hart Museum.

MAP and MAP II were created to provide practical assistance for museums through a network of experienced museum professionals. The IMS provides a grant of $1,400 to qualifying institutions to cover the costs of participation, and the AAM carefully

MUSEUM ON THE MOVE

screens collection managers, curators, directors, and registrars to find appropriate consultants for the program. MAP is a broad review and assessment of a museum's internal operations, while MAP II is specifically geared to collections care and management issues.

The MAP II grant was awarded to the Natural History Museum in the summer of 1989. The assessor's report addressed the strengths and weaknesses of the museum's collection management activities and provided concrete, constructive suggestions for improvement. It will supplement the ongoing planning activities of the staff and will be a valuable document for the future of the museum.

BOTANIST AWARDED NATIONAL SCIENCE FOUNDATION FELLOWSHIP. Curator of Botany Dr. Don R. Reynolds has been awarded a one-year Mid-Career Fellowship by the National Science Foundation to conduct research on molecular systematics at the University of California, Berkeley. The intent of the fellowship is to support those who have been trained in one approach in biology to become proficient in contemporary methods.

Dr. Reynolds is a classical systematist by training—he uses the light microscope and electron microscope to study the structure of fungi for use in identifying individual specimens and discovering evolutionary relationships among groups of fungi. He is now studying molecular techniques to gather the data, which require the extraction of DNA from a specimen and reading its genetic code. Some parts of the DNA evolve faster than others and DNA fragments can be compared from one taxonomic group to another to determine how closely related the organisms are.

The museum's Herbarium specimens now can be used as a source of DNA, and Dr. Reynolds is investigating how museum collections can be used to bridge the gap between classical and molecular biology.

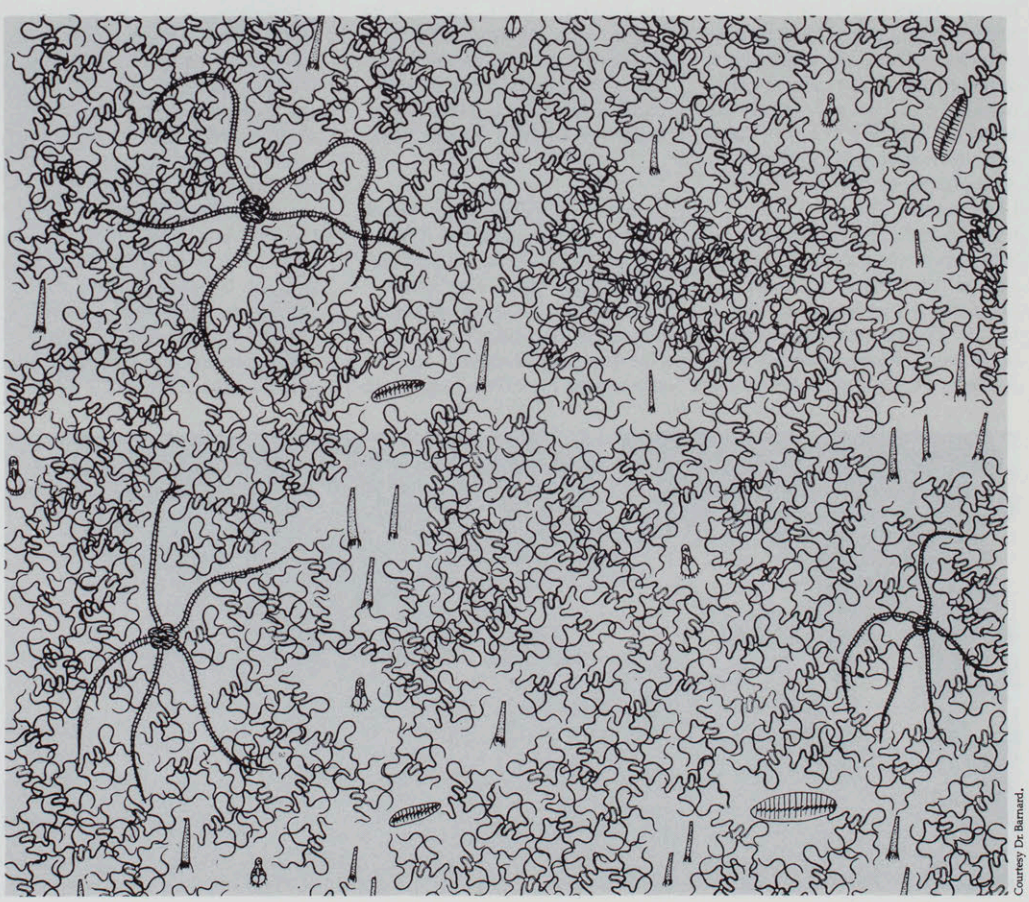
RESEARCH NEWS

CURATOR TAKES BRITTLESTAR BREAK. At the end of 1989 Dr. Gordon Hendler, Associate Curator of Invertebrate Zoology, was offered two scientific trips that he could not refuse. An invitation to give a pair of lectures at the University of Puerto Rico led to a brief visit to that island before Christmas.

Between formal presentations at the main campus of Mayaguez and the Parguera marine laboratory and very pleasant conversations with faculty and students, he could indulge his passion for echinoderms. During a series of SCUBA dives on the southwest side of Puerto Rico, he observed and collected twenty-five species of brittlestars (Dr. Hendler's special interest) and many other marine invertebrates for the museum's collections. A rare chance for a boat ride to the edge of Puerto Rico's continental shelf provided the opportunity for a memorable SCUBA dive. While he floated at sixty feet, the transparent oceanic water permitted a fabulous panoramic view of the miles of coral ramparts that dip precipitously to abyssal depths.

The second invitation took Dr. Hendler as an advisor on a cruise in Santa Monica Bay with a team from the Southern California Coastal Water Research Project (SCCWRP). SCCWRP and Dr. Hendler's interests intersect at a mutual fascination with *Amphioda urtica*. This brittlestar is the most abundant and widespread animal on the southern California coastal shelf. Whales and white sharks come and go, but *Amphioda* dominates marine bottom communities by virtue of sheer numbers–thousands of individuals per square meter. It thrives in clean, uncontaminated sediment, and, for many years, SCCWRP and various local government laboratories have monitored the abundance of *Amphioda* as an indicator of environmental health. Despite its use in pollution surveys, virtually nothing is known about the biology of *Amphioda*. Dr. Hendler's January cruise inaugurated a study that will be made to unravel the reproductive biology and other unknown aspects of this prolific creature.

The brittlestar* Amphioda *is the most numerous and widespread animal on the southern California coastal shelf. Its abundance indicates environmental health; although its numbers are often monitored, little is known of the brittlestar's reproductive biology.

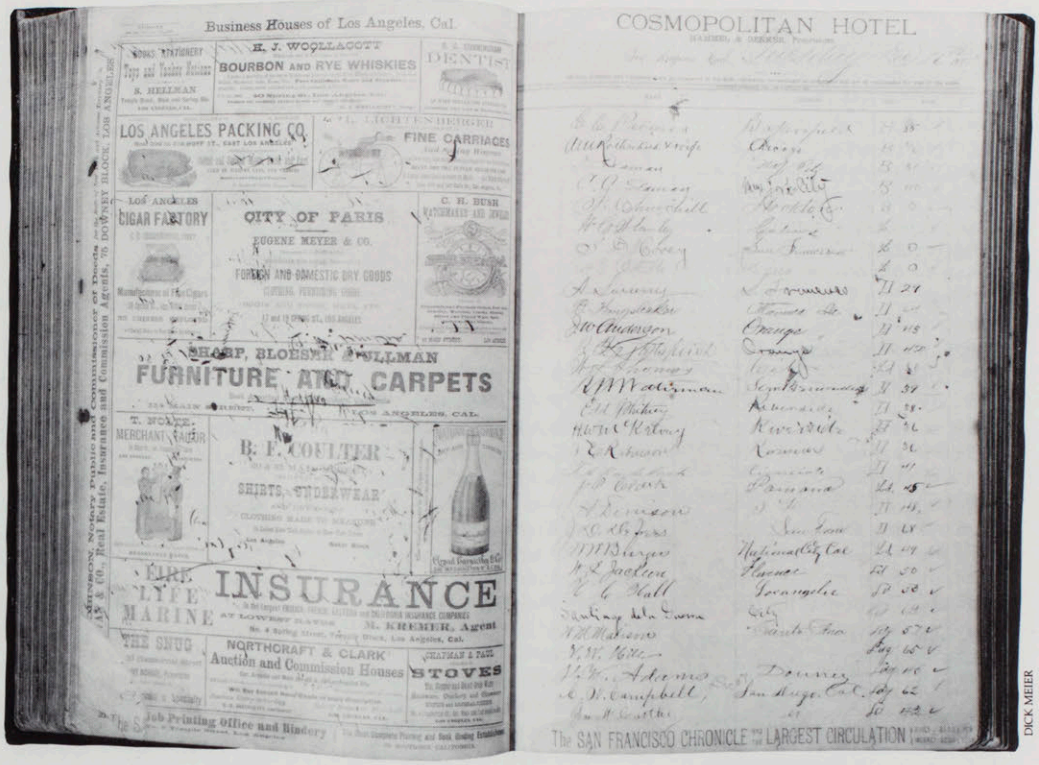


Courtesy Dr. Barnard.

NEW ACQUISITIONS

SEAVER CENTER GIVEN HISTORIC REGISTER, DOCUMENT, AND PHOTOGRAPHS. The Seaver Center for Western History Research, a section of the History Division, recently received three interesting and important donations.

Gerald C. Fitzgerald of Camarillo has given the museum the register of the Cosmopolitan Hotel, Los Angeles, that covers the period October 11, 1882 to February 21, 1883. The Cosmopolitan Hotel, located on north Main Street near Temple Street, was one of the leading establishments of its kind at the time, and visitors from all over the nation stayed in its rooms. Examples of some of the illustrious names that appear in the register are Andres Pico, commander of the Californios who defeated the Americans at the battle of San Pasqual during the Mexican War; E.J. "Lucky" Baldwin, owner of Rancho Santa Anita (present-day site of the Los Angeles County Arboretum); and General George Stoneman who, at the time he signed the register, had just been elected governor of California. The proprietors of the hotel were Henry Hammel and Andrew H. Denker, who also owned the United States Hotel in Los Angeles and the Rancho Rodeo de las Aguas in present-day Beverly Hills. The Seaver Center contains a complementary collection relating to Hammel and Denker's real estate activities. The Cosmopolitan Hotel register is an especially attractive addition to this material.



DICK MEIER

Two pages from the register of the Cosmopolitan Hotel, which covers the period October 11, 1882, to February 21, 1883. The register was recently donated to the museum; the Cosmopolitan Hotel was one of Los Angeles's leading hotels of its day.

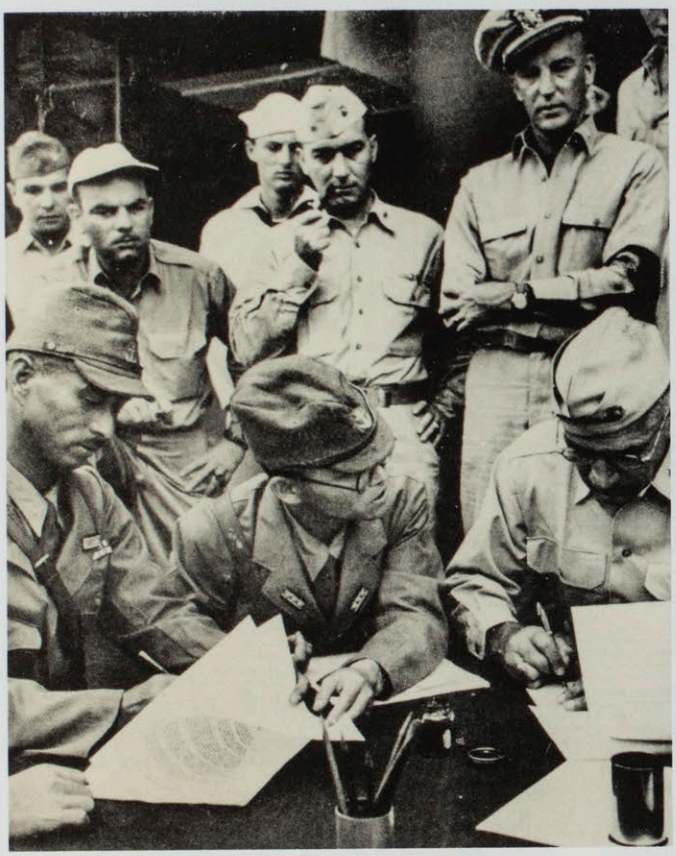
Paul and Evelyn Zettler of North Hollywood have donated a collection of twelve photographic prints and negatives that Mr. Zettler's father took in the Exposition Park area around 1919. These interesting wide-angle shots show views of the temporary stable areas and the grandstand at the time of the 1919 Los Angeles Livestock Show; the festivities taking place in the race track area during the Armistice Day celebration on November 11, 1919; and a patriotic show in the Coliseum in the early 1920s as well as other views of the Rose Garden and State Exposition Building.

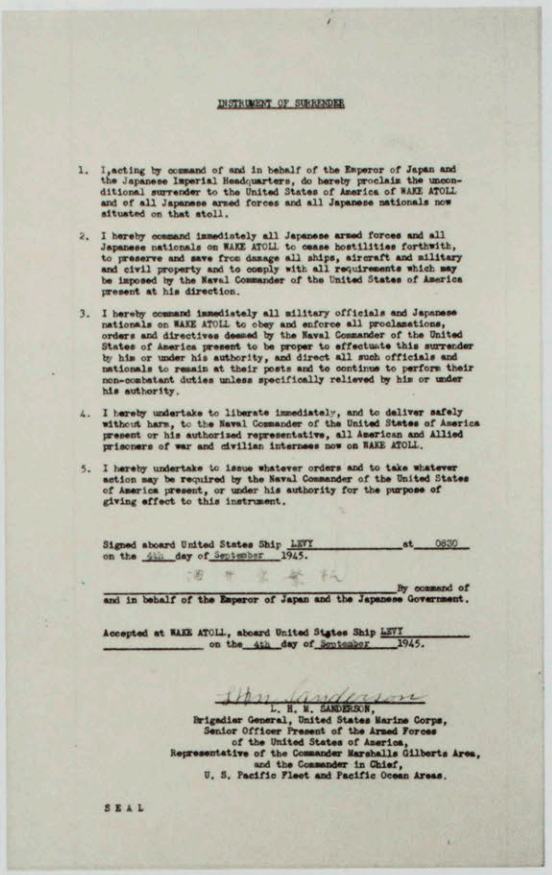
Dr. Kenneth A. Wilson, Research Associate in Botany, has donated a set of the official

An unusual wide-angle view taken in 1919 of the grassy area between what are now the Natural History Museum and the California State Museum of Science and Industry. Eleven similar prints and negatives, all taken in the Exposition Park area, were recently donated to the museum.

papers that marked the surrender of Japanese forces in Wake Island during World War II. The two documents—one in English and one in Japanese—were signed on board the destroyer-escort U.S.S. *Levy* on September 4, 1945. Twelve copies of each of the documents were made at the time. Those presented to the museum are mounted on a board with a photograph from the September 24, 1945, issue of *Life* magazine showing Rear Admiral Shigematsu Sakaibara and Brigadier General Lawson Sanderson as they signed the documents.

These two documents, one in Japanese and the other in English, were signed on board the destroyer-escort U.S.S.* Levy *and mark the surrender of Japanese forces on Wake Island during World War II.





INSTRUMENT OF SURRENDER

1. I,acting by command of and in behalf of the Emperor of Japan and the Japanese Imperial Headquarters, do hereby proclaim the unconditional surrender to the United States of America of WAKE ATOLL and of all Japanese armed forces and all Japanese nationals now situated on that atoll.

2. I hereby command immediately all Japanese armed forces and all Japanese nationals on WAKE ATOLL to cease hostilities forthwith, to preserve and save from damage all ships, aircraft and military and civil property and to comply with all requirements which may be imposed by the Naval Commander of the United States of America present at his direction.

3. I hereby command immediately all military officials and Japanese nationals on WAKE ATOLL to obey and enforce all proclamations, orders and directives deemed by the Naval Commander of the United States of America present to be proper to effectuate this surrender by him or under his authority, and direct all such officials and nationals to remain at their posts and to continue to perform their non-combatant duties unless specifically relieved by him or under his authority.

4. I hereby undertake to liberate immediately, and to deliver safely without harm, to the Naval Commander of the United States of America present or his authorized representative, all American and Allied prisoners of war and civilian internees now on WAKE ATOLL.

5. I hereby undertake to issue whatever orders and to take whatever action may be required by the Naval Commander of the United States of America present, or under his authority for the purpose of giving effect to this instrument.

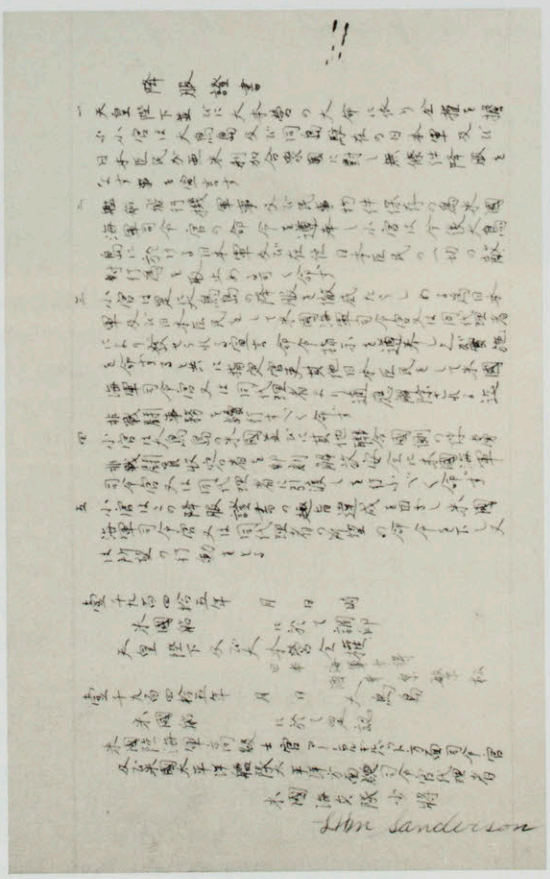
Signed aboard United States Ship LEVY at 0830
on the 4th day of September 1945.

By command of
and in behalf of the Emperor of Japan and the Japanese Government.

Accepted at WAKE ATOLL, aboard United States Ship LEVY
on the 4th day of September 1945.

L. H. M. SANDERSON,
Brigadier General, United States Marine Corps,
Senior Officer Present of the Armed Forces
of the United States of America,
Representative of the Commander Marshalls Gilberts Area,
and the Commander in Chief,
U. S. Pacific Fleet and Pacific Ocean Areas.

SEAL



Continued on p. 44

SHARKS
A Portfolio

"The shark was not an accident. He had come from deep down in the water as the dark cloud of blood had settled and dispersed in the mile deep sea....He was a very big Mako shark built to swim as fast as the fastest fish in the sea and everything about him was beautiful but his jaws. His back was as blue as a sword fish's and his belly was silver and his hide was smooth and handsome.... This was a fish built to feed on all the fishes in the sea...."

(Ernest Hemingway, *The Old Man and the Sea*, 1952)

As Hemingway suggested in his classic short story, sharks are known as efficient eating machines. Many sharks, however, have more to fear from being eaten by humans than people do from being eaten by sharks. Attacks by pigs, strikes by lightning, and dying from bee stings are all more likely than a shark attack; nonetheless, many of us feel trepidatious when we venture in the ocean. Could a hungry white shark be lingering nearby?

There is more to the fascination we feel for sharks than mere danger: they are impressive for their amazing variety–sharks comprise a class of fishes that have evolved to fill an astonishing number of underwater niches. For example, the largest fish in the sea is a plankton-eating shark (see page 11 for a photo of the whale shark), but some sharks, such as the spined pygmy shark, are little more than six inches long and live obscure lives in the ocean depths. Yet one of the very largest sharks also lives a very obscure life: the megamouth shark is about fifteen feet long, but was not discovered until 1976–hard to believe that something that big could have been overlooked in the well-fished waters off Catalina Island for so many years. But sharks are full of surprises.

Sharks and their allies, the rays, skates, and chimeras, are different from all other fishes. Sharks have backbones, as do the bony fishes, but in the case of the sharks, that backbone–and the rest of the skeleton–is made of cartilage rather than calcium-impregnated bone. This basic shark blueprint evolved more than 450 million years ago and has changed little in the last 100 million years.

The body shapes of the 360 species of sharks vary widely from the torpedo-shaped white shark to the flattened carpet shark to the peculiarly pated hammerhead shark. Sharks have a wide range of preferred foods and methods for feeding; not all sharks have the great white shark's terrifyingly sawlike teeth. Some have less formidable but no less lethal awl-shaped teeth for grabbing prey while others have blunt teeth for crushing mollusks. The whale, basking, and magamouth sharks barely have teeth at all; instead these leviathans strain tiny sea animals through their gill slits.

Sharks live in nearly every oceanic habitat on earth, save, perhaps, in Antarctic seas. They live in shallow coastal waters and at very great depths, from the tropics to the Arctic. While some, such as the bull shark, even venture into fresh water and have been found in Lake Nicaragua, the Zambezi (eastern Africa), Hooghly (India), and Tigris (Iraq) rivers, no shark lives in a land-locked body of fresh water.

Although sharks exhibit a variety of lifestyles, they do hold many characteristics in common besides sharing a cartilaginous skeleton. Most sharks:

- are streamlined and torpedo shaped (with some interesting exceptions, as noted);
- have five gill slits, although some have six or seven;

Basking sharks **(Cetorhinus maximus)** *cruise slowly through the water feeding with their mouths open. Long, hair-like gill rakers line the inside of their gills, straining plankton from the water as it flows past. This shark can filter more than one thousand tons of water an hour.*

HOWARD HALL

• have two dorsal fins (one of which is the characteristic fin slicing through the water that we identify with sharks);
• have a pair of pectoral and pelvic fins (see the hammerhead photo on page 13 for a view of these fins);
• have a protruding snout with nostrils near the tip and a crescent-shaped mouth (see the blue shark on the cover); and
• have abrasive, rough skin covered with tooth-like scales called denticles, completely unlike the scales of bony fishes.

These features and others are presented in the portfolio of shark photographs that follows, which shows sharks in their amazing diversity, from small to very large, from unobtrusive to very common, and from fierce to very mild.

The Natural History Museum's exhibition **Sharks! Fact and Fantasy** aims to tell the true story of these much maligned and misunderstood inhabitants of the seas. It is the largest and most comprehensive exhibition about sharks ever mounted and has been designed to encourage visitors to participate actively and have fun while learning. Made possible by the generous support of the National Science Foundation, the exhibition will tour the United States and Canada following its debut at the Natural History Museum June 30 through September 23, 1990.

Sharks is a special ticketed exhibition and museum members receive two free tickets; see the June/July *Calendar* for more information.

—*Kathy Talley-Jones*

CHIP MATHESON

This white shark **(Carcharadon carcharias)** *is about to bite a dummy clothed in an experimental protective dive suit made of Kevlar. Although Kevlar can protect against bullets, it wasn't strong enough to withstand the force of the shark's bite. The triangular teeth of the shark slash chunks of flesh from its prey: marine mammals such as seals, sea lions, and dead whales.*

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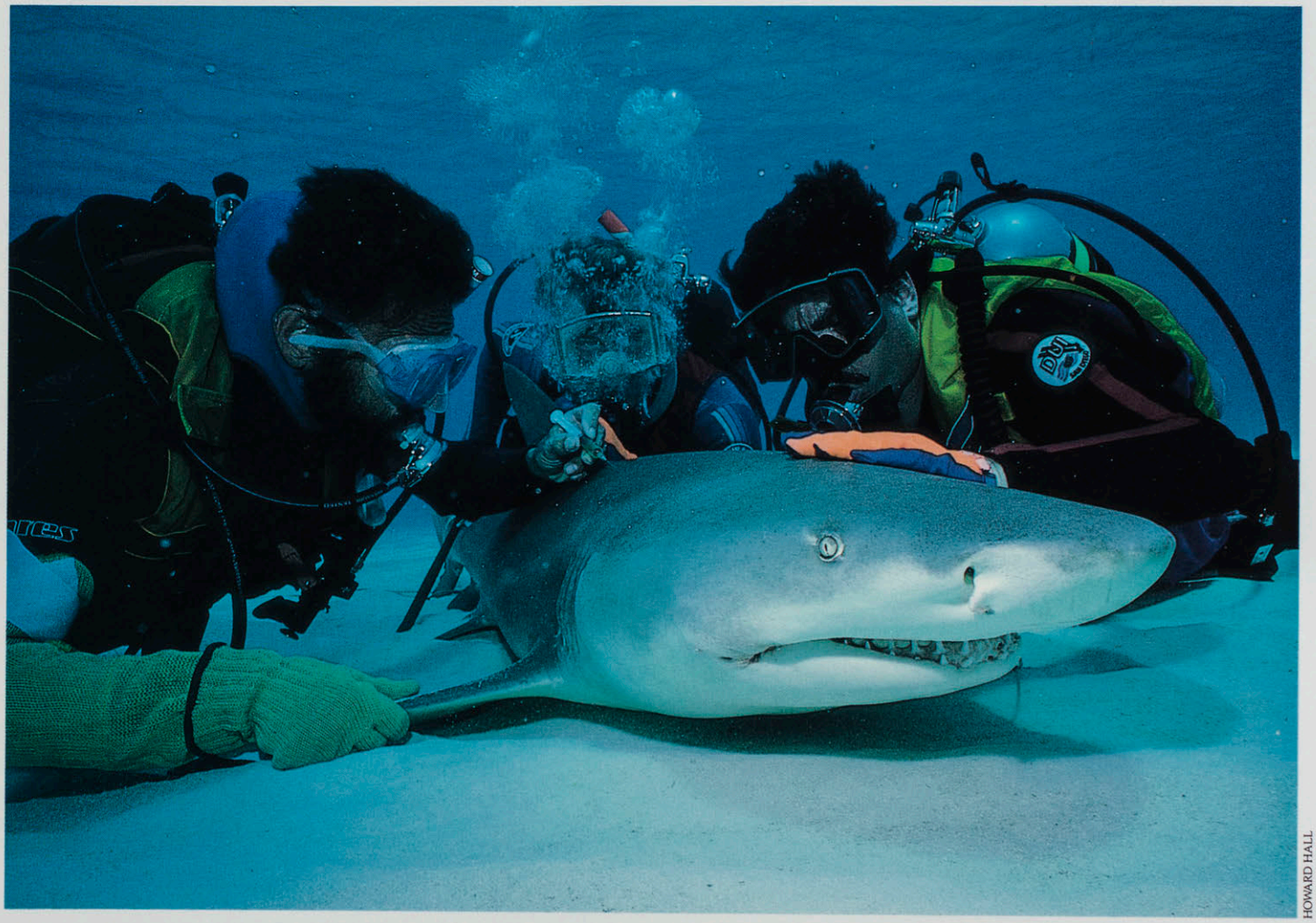
The whale shark **(Rhincodon typus)** *is the largest shark and may grow to be sixty feet long. This enormous shark feeds on tiny plankton.*



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These ichthyologists are injecting a shark with tetracycline. The antibiotic stains the shark's vertebrae so that alternating light and dark rings stand out; these rings can be counted to determine the shark's age.

Why does the hammerhead shark have such an unusually shaped head? Sharks smell their prey through their nostrils, which are prominent in the photographs of the blue shark on the cover and the white shark on page 10. Some sharks can detect one blood molecule among one million molecules of seawater. Moving the nostrils farther apart may improve a shark's ability to determine what direction an odor is coming from. This may be one reason why the hammerhead's nostrils are located on each side of its head.

HOWARD HALL

Further Reading

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Reading list compiled by Sara Crump.

CHUCK DAVIS

CHIP MATHESON

Compared to bony fishes, sharks produce only a few, large, well-developed young. This swell shark egg case, known to some as a mermaid's purse, protects the shark embryo until it hatches (below).

CHIP MATHESON

The eyes of this reef stingray **(Taeniura lymma)** *are adapted for vision in murky waters.*

A stingray passes overhead, its mouth and nostrils clearly visible. The eyes are on the top side, out of view.

Almost anyone who goes near the ocean knows that there are some marine animals that are simply better left alone because of the danger that they pose to humans. This is especially true for most cartilaginous fishes, the sharks, skates, and rays. Books and experienced watermen routinely admonish swimmers and fishermen to avoid coming in contact with stingrays, which, when disturbed, can impale a person with their three- to five-inch-long tail spines, causing a painful and easily infected wound. Picture then, the unexpected sight on a tropical Caribbean island beach of children and adults in the surf playing and cavorting with stingrays: petting them, grabbing them, and sitting on them with no casualties.

This is the special situation at Honeymoon Beach on Saint John Island in the U.S. Virgin Islands, Lesser Antilles, West Indies, where visitors almost daily feed certain stingrays (genus *Dasyatis*) by hand in very shallow water. More incredibly, the stingrays literally beg for food and, in doing so, sometimes even swim into people's legs, occasionally knocking them over in the surf. People are even able to hold onto the stingrays and sit on their backs without eliciting any apparent aggressive reactions.

Visitors to Honeymoon Beach, which is near the U.S. Virgin Islands National Park, have been enticing stingrays into shallow water with food and interacting with them in this maner for at least seven years, primarily as a result of boat owners having brought tourists to the site for recreational activities. Certain individual stingrays now regularly come from offshore into very shallow water, less than three feet deep, to take small pieces of fish from people.

Apparently the first person to begin to accustom the stingrays at Honeymoon Beach to human presence was Jimmy Lovelin of neighboring Saint Thomas Island. Mr. Lovelin had a day sail operation for tourists, and in about 1983 he began attracting the rays into the surf zone so that his clients could get a closer look at them. He attracted the rays by scattering fish entrails, obtained from a Saint Thomas restaurant kitchen, in the water. Sub-

THE TAME STINGRAYS OF SAINT JOHN ISLAND

L. G. BARNES

Honeymoon Bay, Saint John Island. R. O'Dell awaits arrival of stingrays.

by LAWRENCE G. BARNES
SUSAN E. BARNES, and
RICHARD W. O'DELL

sequently, several other boat operators began doing the same thing at Honeymoon Beach. By 1988, six individual stingrays, two adults and four smaller animals, could predictably and routinely be attracted into the surf to feed and to interact with people.

Sharks and rays are not particularly known for their ability to learn, or to be conditioned to respond to stimuli, from humans. There have been, however, a few published and anecdotal reports of such behavior among both captive and wild chondrichthyans, apparently more frequently among skates and rays than among the sharks. The behavior described and documented here has been observed and has developed only over the past seven years at Honeymoon Beach.

The stingrays of Saint John Island have the typical identifying features of members of the genus *Dasyatis* that distinguish them from other rays. Rays in the genus *Dasyatis* have a pointed snout; pectoral fins with broad, rounded tips; and a long tapering tail that bears a single, long, backward-directed spine on the top surface. This is the dangerous spine! It is a defensive weapon, has small, recurved barbs on each side, and is covered by thin, mucousy skin. The ray's eyes are located in eminences on top of the head, while the mouth is on the bottom. The top of the body is a uniform grayish-black; its bottom is creamy-white. On the back are rows of backwardly-directed dermal denticles (small spines). The middle row of these denticles extends from the head area onto the tail to just in front of the tail spine, and there are two short rows behind the head on either side of this middle row.

On 12 December 1987 and 1 April 1988, the authors sailed to Honeymoon Beach on Richard O'Dell's boat, *Halcyon Days*, to observe and photograph the stingrays. Usually the beach has a gentle slope and a coral sand substrate, the situation we found in December. On our return trip the following April, however, strong surf, driven by exceptionally high winds, had cut away the beach leaving only a narrow shelf with an abrupt drop-off of nearly ten feet. The shoreline on both sides of Honeymoon Beach supports mixed corals growing on a volcanic rock substrate, and these attract a typical coral reef fish association.

Underwater visibility is usually quite good at the site, ordinarily at least twenty-five feet. To record the events, we used a variety of cameras (Hanimex amphibious camera with a 35 mm wide angle lens, a Pentax K-1000 single lens reflex with a fixed focal length 28 mm wide angle lens in an Ikelite underwater housing, a Nikonos 35 mm underwater camera, and a Minolta 110 underwater range finder).

Whenever we have had two or three stingrays around us, we often have been joined in the water by as many as ten other curious people, including children. With two or three stingrays swimming amongst this many people, in water varying from six inches to six feet deep, the commotion can make it difficult to observe and photograph the stingrays. At the same

ROBERT PECK

time, however, this situation has allowed us to see and document some unusual behavior and has yielded some interesting photographs. In December 1987, we spent approximately one hour observing and photographing the stingrays with people and interacting with the stingrays ourselves. In April 1988 we spent about four additional hours photographing and observing the rays. In July 1989, Mr. Robert Peck returned to the location to make additional photographs.

In the same area where the stingrays come to feed, there are usually schools of from five to fifteen sergeant majors (*Abudefduf saxatilis*) swimming at various depths. Curiously elongate halfbeaks (*Hemirhamphus brasiliensis*, also called ballyhoos) swim just below the surface of the water. The stingrays are commonly accompanied by schools of up to fifteen to twenty-five jacks (*Caranx* spp.) about twenty inches long. When people first arrive at Honeymoon Beach in the morning, these same stingrays are usually about fifty yards offshore in twenty-five feet of water lying, partly covered, on the coral sand bottom, which is how stingrays normally act when they are not foraging for food. Some days, however, they are already in the surf zone when the first people arrive. If the rays are not already in the surf zone, they must be attracted by baiting the water. Typically, this is accomplished by cutting up small fish, usually halfbeaks, which are placed in a plastic bag filled with sea water. This bag is repeatedly emptied into the sea and refilled with water, and it is apparently their olfactory sense that brings the stingrays near the shore in search of the food. Sometimes this can take as little as five to ten minutes. On choppy and windy days, the fish "scent" in the water becomes more dispersed, and it may take up to forty-five minutes for the stingrays to move into shallow water. Halfbeaks are common at the site, but unless they are attacked and maimed by some other predator, they are probably not usually eaten by stingrays.

DEAN GRISWOLD

A large stingray in very shallow water being photographed by L. Barnes while it is observed by Wendy Smith-Griswold and petted by Susan Barnes.

One of the smaller stingrays in water less than eight inches deep at Honeymoon Beach.

DEAN GRISWOLD

Once the stingrays move into shallow water, they swim slowly in large circular and figure-8 foraging patterns. They move quickly back and forth between water that is four feet and only about ten inches deep, ususally staying very close to the bottom. During each circling maneuver, each ray may approach at least one person. It is usually

possible to attract a stingray by holding cut portions of halfbeaks just under the water's surface. The stingrays approach people and will raise their heads, sometimes partly out of the water, to take fish parts that are offered to them. The fish parts are taken with a slight sucking action. Rays will persist in trying to reach anyone who will extend a hand, and it is even possible to attract a ray by holding an empty hand in the water, whereupon an approaching ray will take your fingers in its mouth. The inside of a stingray's mouth feels somewhat like a wood rasp because of the many rows of small, pointed teeth, but these are virtually harmless to people. In its excitement to feed, a ray may mouth a person's arms, legs, or swim fins. Even grabbing or falling onto one of these stingrays will not cause it to exhibit any sort of extreme defensive or offensive behavior.

As a stingray swims past, it is possible to hold onto its pectoral fins and tail and to stroke and rub it on its upper surface, along the rows of denticles, and along the tail with its long spine. The rays swim with such persistent force that it is difficult for even an adult person to push one aside. Sometimes a ray will approach someone from the side or even the rear. In doing so, the ray may actually force itself between a person's legs, throwing him or her off balance and into the water onto the ray's back. In such circumstances, the rays tend to show little change in behavior. They usually wriggle or squirm a bit under a person's weight and merely swim out from under the person. We saw no other defensive or offensive behavior by any of these six rays.

An example of this happened during our visit in December 1987. One of the large stingrays swam into Susan Barnes's legs after an approach from her right side. The ray's snout struck her right ankle and her left leg flailed the water's surface as she lost her balance. She fell onto the ray, landing squarely

Caribbean area with Saint John Island located.

on its back, after which it swam out from under her. We have never seen one of the Honeymoon Beach rays elevate its tail or in any other way behave as though it were attempting to impale anyone with its spine, and we have heard of no injuries caused by stingrays at Honeymoon Beach during the seven years that people have been feeding them.

When the rays are no longer offered chopped fish, they seem to lose interest in people. They begin swimming in increasingly larger circles, moving farther offshore each time, until they are about fifty to one hundred feet from shore. The rays are always fed at the same location on Honeymoon Beach, and this is done almost daily by O'Dell and a few other boat operators. Only six stingrays appear to display this behavior, although all of them do not necessarily show up for each feeding. The different individuals can be recognized by their sex (males have claspers, appendages below the tail), size, and color. Of the six tame stingrays that we have seen, the larger ones are nearly five feet across their pectoral fins and the other smaller ones are approximately two feet across.

A similar phenomenon exists on nearby Saint Thomas Island, where some stingrays stay most of the time around an underwater observation tower at Coral World and take pieces of food from divers. At Grand Cayman Island, 1,100 miles west of Saint John Island, in the Antillean archipelago, there is a location called "Stingray Alley" or "Stingray City," where wild stingrays also approach people for food (*National Geographic*, January 1989). The animals were first attracted by discarded fish parts, but divers have subsequently reinforced their behavior by feeding them halfbeaks in an almost daily ritual. Such stingrays as we have described at Saint John Island are not really tame in the sense of the word as it applies to pets. They are wild, free-living animals; however,

L. G. BARNES

A large stingray approaches Susan Barnes to accept a piece of fish. Its long tail is casually brushing an observer's arm.

L. G. BARNES

In water only a few inches deep, a large stingray swims into the ankles of a woman. It will push its way right between her ankles, knocking her off balance.

they have become accustomed (habituated) to coming near shore in response to certain stimuli. We suspect that, in addition to the scent of fish, both the sight and sounds of humans in the water now attract the stingrays at Honeymoon Beach. In contrast, the bony fishes that swim with the rays have not become trained to take food.

Captive lemon sharks and nurse sharks have been trained to respond to food stimuli. Common reef fishes have also been trained at numerous locations to accept food from divers and have become quite tame. There are other examples of apparently "friendly" behavior among wild aquatic mammals after repeated contact with humans (frequently tourists): gray whales in Baja California, humpback whales off the coast of New England, and bottlenose dolphins at Shark Bay, Australia, and off the coast of Great Britain.

Predictable and repeatable, human-modified behavior in chondrichthyans is a little-studied phenomenon. Our story documents the history of habituation of stingrays at a single locality. We note that apparently only six stingrays are involved at Honeymoon Beach. We have documented, albeit in an anecdotal fashion, an interesting phenomenon that also has the opportunity for future significant research.

Questions are posed by our revelation. Could other stingrays enter the area and join in the activity or do the six for some reason competitively exclude them? Have the stingrays become overly dependent on an artificial feeding situation? Would they revert to their original diets and feeding behaviors if visitors ceased feeding them? How much of their time do they spend behaving like "normal" stingrays? Could one of these stingrays be provoked to the point where it would do bodily injury to a person? How far offshore do the stingrays move when not feeding from people? Is there any sort of seasonal variability in their presence, movements, or abundance? All these questions would be fertile field for behavioral research.

A word of warning. This behavior is not typical of all stingrays, and in other locations we would be very apprehensive about treating stingrays as casually and intimately as we have on Saint John Island. But the tame stingrays of Saint John are truly different and provide an experience that is rare and memorable.

Acknowledgments

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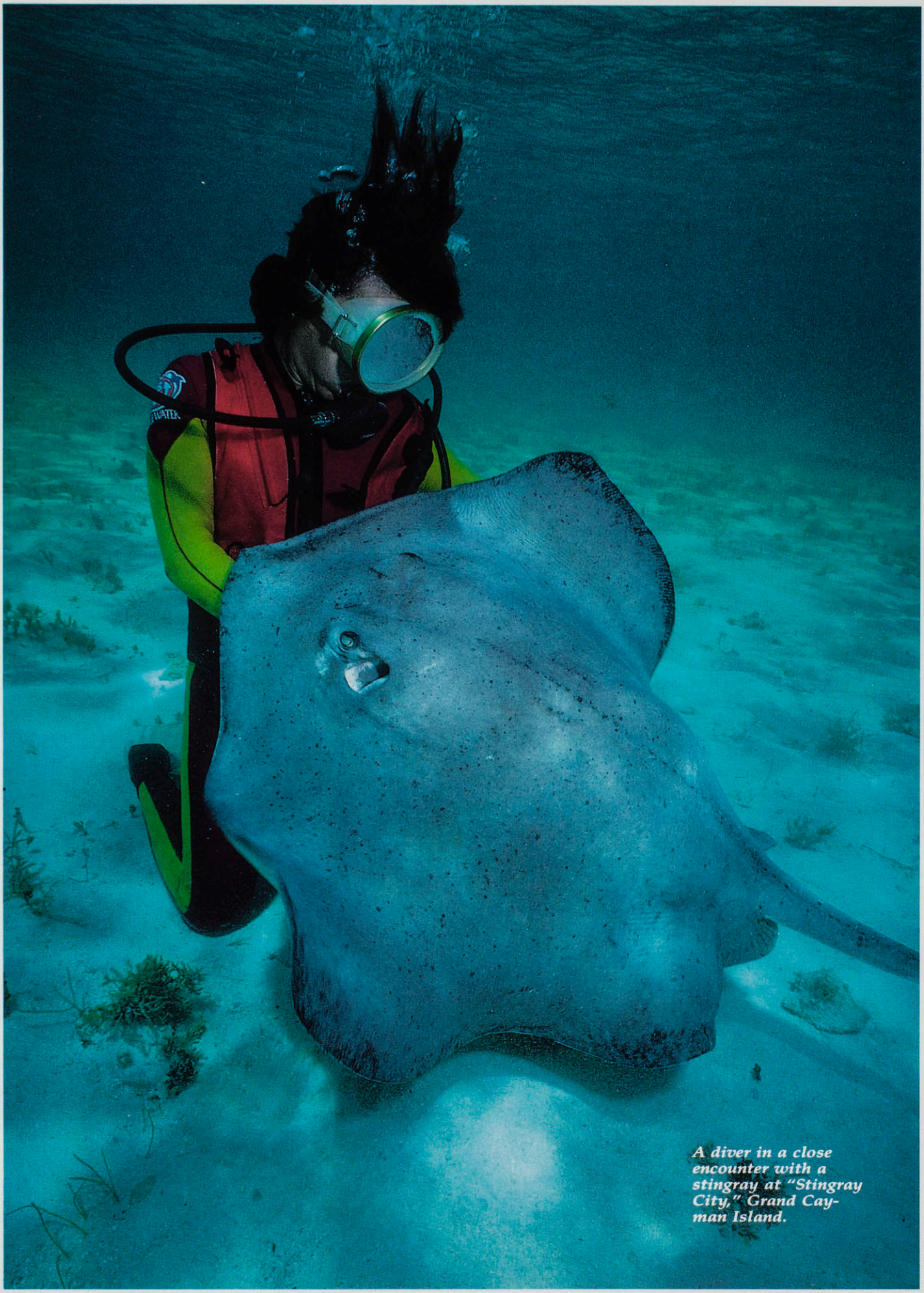
Dr. Lawrence G. Barnes is Curator and Section Head of the museum's Section of Vertebrate Paleontology. His area of research is marine vertebrates, and he has published articles and book chapters on the evolution, distribution, and classification of whales, dolphins, and sea lions. This is his fourth article in TERRA. *Mrs. Susan E. Barnes, his wife, a museum volunteer for over fifteen years, has had a long-time interest in marine biology and in diving. Mr. Richard W. O'Dell owns the sailboat* Halcyon Days *and operates it in the U.S. Virgin Islands (Halcyon Days, P.O. Box 57, Red Hook, St. Thomas, U.S. Virgin Islands, 00802, U.S.A.). He has been active in habituating the stingrays on Saint John Island and brought the phenomenon to the attention of Dr. and Mrs. Barnes.*



A diver in a close encounter with a stingray at "Stingray City," Grand Cayman Island.

HOWARD HALL

TROPICAL FOREST CONSERVATION
Challenges and Solutions

by JUDITH GRADWOHL

Diversity is the key to understanding the natural history, causes, and consequences of the widespread destruction of tropical forests. Crowded into a mere 6 percent of the earth's land surface, forming a belt around the equator, tropical moist forests are home to probably half of all species on earth. Probably half, because the absolute numbers of species are unknown. A single acre of tropical forest in Asia, for example, can have 120 or more species of trees. The country of Colombia, which is around the size of Texas and New Mexico combined, has twice as many species of birds as the United States plus Canada. Scientists estimate that there may be between four and thirty million species of plants and animals in the world's tropical forests and that as many as ten species are lost to extinction every hour due to deforestation.

As devastating as these numbers may seem, tropical forest species extinctions may also represent a tragic, permanent loss of potential medicines, food plants, and other useful species. We in the developed world rely upon breeding wild strains of food plants to confer disease and pest resistance to our staple crops. We rely upon plants for one quarter of our pharmaceuticals, and many of these species originate in tropical forest regions. We would sorely miss a host of other products from the tropics used in spicing our food, cleaning and maintaining our homes, and in beauty and health care.

We also stand to lose biological diversity in the temperate zone, if present trends continue. For instance, ornithologists have already documented declines in breeding populations of North American warblers, vireos, and thrushes due to deforestation on their wintering grounds in Central America and the Caribbean. These birds are beautiful, lively spring and summer denizens of the forests of northeastern United States and Canada, and they are also major predators on leaf-eating insects. If their populations continue to decline, it could eventually affect trees in the northern forests.

Intact tropical forests also provide valuable ecological services to tropical countries and the rest of the world. During torrential rains, tropical forest vegetation absorbs much of the water, preventing heavy floods and moderating runoff. The very presence of forest vegetation also helps prevent soil erosion, as the roots of plants stabilize the soil. When a forest is cleared, dramatic flooding and loss of topsoil can occur. The frequent and tragic floods in Bangladesh and their human toll are directly attributed to deforestation of the slopes of the Himalayas. Soil loss from cleared land can be a severe problem. A study conducted

CHARLES L. HOGUE

Indigenous peoples of the Amazon rainforest use the secretions of the poison arrow frog (in this case,* Dendrobates quinque vittatus*) in their hunting; some of the compounds present also have medical uses. Many modern medicines owe their existence to rainforest plants and animals, yet fewer than 1 percent of tropical forest species have been examined for their chemical compounds.

A view looking up into the rainforest canopy, Mulu National Park, Borneo. The tropical forests of Asia are among the richest in plant and animal species. In a single acre of forest in peninsular Malaysia, botanists found over 120 species of trees.

STEVE BROSNAHAN

in the Ivory Coast found that on a 7 percent slope, cleared land lost 138 tons of topsoil from 2.5 acres per year, over 450 times more soil loss than in an intact forest. As the soil washes away, it silts up streams, chokes dams, and eventually can wreak havoc with marine fisheries when it reaches the oceans. In extreme cases—as in the country of Haiti, where only around five percent of the original forest remains—topsoil loss was so great that half the potential agricultural land is now exposed bedrock.

The loss of tropical forests may also have a profound effect on climate. Around one-fifth of the excess carbon in the atmosphere, which may contribute to the global greenhouse effect, is ascribed to the burning of tropical forests in preparation for planting crops. Tropical forests also affect local weather patterns. Climatologists believe that around half the rainfall in the Amazon Basin is generated by water vapor produced by forest vegetation as it respires. When the water vapor combines with clouds moving east over the Amazon, it creates rain. Forest clearance could create local drying, which could, in turn, affect weather elsewhere.

Social, economic, and political problems also stem from tropical deforestation. When forest loss and soil erosion are severe, as in the countries of Haiti and El Salvador, subsistence farmers are no longer able to grow food for their families. This creates a class of environmental refugees who flee the land to emigrate or become destitute in the slums of cities. It is being increasingly argued that the future axis of international dispute will be north-south rather than east-west, due to disparities in wealth exacerbated by impending environmental disasters in the tropical world.

It is perhaps the Indians, the tribal peoples, who are hardest hit by tropical forest development and deforestation. Populations of tribal peoples in the New World have declined by 95 percent since the arrival of Christopher Columbus, nearly five hundred years ago. Most of the deaths were due to European diseases for which New World people lacked immunity. Today the few remaining tribal peoples are severely threatened by development of their lands. Not only is the world losing some of the rich diversity of human culture, it is also losing valuable knowledge that tropical forest people have gained over thousands of years of life in tropical forests.

The Rate of Loss

Today tropical forests grow on only slightly over half of the area they once occupied, and they are falling at an ever-increasing rate. Data from the United Nations Food and Agriculture Organization collected in the late 1970s show a worldwide deforestation rate of between 1 and 2 percent total area of forest lost each year. But these data are admittedly out of date. More recent information reported from the Brazilian Amazon showed an exponential rate of deforestation between 1975 and 1980. By 1988, reports showed local deforestation rates as high as 15 percent of the forested area being cleared each year, and similarly high local rates have been reported elsewhere.

Causes of Deforestation

The most familiar symbol of tropical deforestation is the chainsaw. Droning in the sound tracks of news clips, and pictured slicing into the hearts of ancient rainforest trees, chainsaws have received their share of bad press. And not without good reason: around 12.5 million acres are deforested each year during timbering operations. Tropical wood sales are big business–the hardwood trade alone is worth nearly $8 billion annually. Much of the damage caused to tropical forests by logging operations occurs because of the use of heavy machinery. In some areas, two-thirds of the nontarget trees are damaged during felling and removal of valuable trees. In addition to the need to clear large areas for roads and turnarounds, heavy machinery compacts the soil and makes natural regeneration more difficult.

It is more difficult to measure the area cleared each year for subsistence agriculture, because although it is practiced by an estimated 240 million people, they are dispersed throughout the tropical realm. Because most tropical forest soils are poor, farmers burn the cleared vegetation and improve the soil with nutrient-rich ash. This method of agriculture, popularly known as *slash-and-burn* or *swidden* agriculture, has been practiced throughout the tropics for thousands of years. As an agricultural method it is not inherently destructive—if the land rests for fifteen to thirty years between plantings it can be reused. Problems only result when too many people need to use a limited amount of land—a situation that will become increasingly problematic as populations in tropical countries grow explosively.

Large-scale agriculture also contributes signifi-

Tropical Rainforests

A Disappearing Treasure

Through May 27, 1990
Governors Gallery

Tropical Rainforests: A Disappearing Treasure emphasizes the fragility of the tropical forest ecosystem and the necessity for maintaining its unsurpassed biological diversity. By using dioramas, photo murals, video stations, interactive exhibits, models, ethnographic objects, and scientific specimens, the exhibition explores rainforest ecology, peoples, and conservation issues, including the causes and consequences of deforestation and possible methods to preserve forests or use them wisely.

The following sponsors contributed locally to the exhibition and its related educational programming. Our sincere thanks for their efforts to inform the world of this disappearing treasure go to the World Wildlife Fund, Citicorp, Allied Signal Aerospace Company, Chevron U.S.A. Inc., JCPenney, the John D. and Catherine T. MacArthur Foundation, and the J. Douglas and Marian R. Pardee Foundation.

Tropical Rainforests: A Disappearing Treasure was organized by the Smithsonian Institution Traveling Exhibition Service (SITES).

cantly to the loss of tropical forest. Although it covers a smaller area than subsistence agriculture, the presence of large agribusiness operations determines the patterns of land use. Generally the best agricultural land belongs to large-scale operations and the subsistence farmers are forced to farm in marginal areas–on more fragile soils and slopes.

Around five million acres are converted into cattle ranches each year in Latin America. Unfortunately, cattle ranching is an even less efficient use of tropical forest land than poorly practiced agriculture. The productivity of grasses and other fodders declines precipitously after the first few years, so cattle must be kept at extremely low densities. Fires used to control weeds and the soil compaction caused by the hooves of cattle act to slow the regeneration of vegetation on abandoned cattle ranches.

Most large-scale development projects are designed to raise the low standard of living in tropical countries or reduce overcrowding in urban areas, but they are also major contributors to tropical deforestation. Even a simple dirt road cut into pristine forest can create significant problems, because roads create access for loggers, speculators, and subsistence farmers. Some development projects involve planned resettlement of people into a frontier area or out of a site about to be inundated by a reservior. These projects not only destroy intact forest but disrupt or devastate the lives of thousands of people. Hydroelectric projects are particularly damaging because they drown large areas of forest, kill plants and animals, and displace people.

To understand tropical deforestation fully, one must examine the underlying economic and political causes. Trapped by staggering debt burdens and skyrocketing populations, most tropical countries can be expected to tax their few remaining natural resources by the turn of the century, if they have not already done so.

Anyone holding a mortgage or other large loan can sympathize with developing countries struggling under massive debt burdens. The typical formula for home loans from American banks requires that the loan payments should not exceed 20 percent of the debtors' income. However, many developing countries, particularly those in Latin America, are devoting over a third of their export earnings to service debt acquired in the early 1970s. Brazil alone owes more than $110 billion and spends 33 percent of its export earnings to service the interest on those loans.

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A view of the rainforest as seen from Rio Cayeru, near Leticia, Colombia. Amazonia contains the largest expanse of rainforest in the world.

Although Brazil is an extreme example, economists fear a global economic crisis over the nearly $1 trillion owed to banks by developing countries unless some debt relief is found. Outright forgiveness is one major option, if it is linked to environmental concerns. However, the economic restructuring and austerity programs required by the International Monetary Fund and multilateral development banks as a condition for loan rollovers can serve to destroy funding for social and environmental programs.

Demographers predict that the global population, presently around 5.2 billion, will reach 6.2 billion by the turn of the century. More than 90 percent of the projected growth is expected to occur in the tropics. Rapidly growing populations will increase demand on limited resources and create or exacerbate environmental problems. The effects of a growing population on tropical forests are amplified by the unequal distribution of land and wealth in most developing countries. In Latin America, for example, only 7 percent of the population controls 93 percent of the agricultural land, and over half of the rural population is legally landless. The marginal or inadequate growing conditions can force subsistence farmers to move more often and use more forested land than is necessary on richer soils.

Potential Solutions

Given the diversity and interrelatedness of the causes of deforestation, is there any hope of halting or reversing the decline of the world's tropical forests? It may be too late for a large portion of the forests, but there are many techniques in development or practice that may help to slow or stop deforestation in local areas. Large wildlife reserves will ultimately be needed to preserve biological diversity in the tropics, but the old concept of heavily guarded and securely fenced national parks as pristine wilderness areas has undergone a complete metamorphosis. Environmentalists and political leaders now recognize that reserves are destined to fail if they do not benefit people as well as wildlife. The new focus for parks and reserves is on multiple use—portions designated for wildlife and areas demarcated for extractive use by local people.

Extractive Reserves

In December 1988, after the brutal assassination of the Brazilian rubber tapper leader Chico Mendes, world attention focused on extractive reserves in the Brazilian Amazon. Mendes' death was blamed on cattle ranchers—the latest casualty in an escalating war over land-use rights between speculators, tribal people, and peasants. In rural Brazil 70 percent of the households do not hold legal title to their land. The extractive reserves approved by the Brazilian government legalize the rights of rubber tappers to use the forest land their families have been working for generations.

What sets these reserves apart from other land tenure disputes is that rubber tappers and other extractivists do not need to clear forest to make an adequate living. The extraction of forest products is potentially as lucrative as other more

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destructive forms of land use in the area, such as cattle ranching and agriculture, and more important, extractive activities will continue to produce income for many years. Rubber, Brazil nuts, and a host of other useful plant and animal products were valued at $26 million in the Brazilian state of Acre in 1980.

Botanists and anthropologists have long recognized the value of minor forest products or nonwood products, throughout the tropics. Although no single commodity approaches the market value of tropical forest timber, the sheer number and diversity of products collected make them an economic force to be contended with. The world trade in rattans, for example, is worth roughly $45 million annually for raw material and around $1 billion including trade in rattan products. Bamboo, other fibers, fruit, seeds, resins, and medicinal plants are all products that can be extracted from relatively intact forest.

Extractive Timbering

It is crucial to make a distinction between the *extraction* of products that are potentially renewable for many years and *mining*, in which products are removed in a manner that precludes subsequent use. Although there are techniques developed for sustainable forest management for timber, in practice most forestry in tropical moist forests is mining. Sustained-yield timbering requires careful removal of logs and allowing the forest to regenerate for thirty or more years. Sustainable techniques include minimizing damage to nontarget trees through careful felling patterns and log removal using light machinery or animals. Several innovative logging schemes involve clearing small areas, leaving adjacent forest intact and mimicking the damage done by a large natural tree fall. Sustainable forestry techniques developed over forty years ago in Malaysia involve killing plant competitors and encouraging the growth of young economically valuable trees.

These techniques require skilled field workers and are more expensive in the short term, although their use could yield timber from the same land for many years. Unfortunately, sustainable methods are rarely considered economi-

Swarming army ants in Peru. Ants are ubiquitous in the rainforest. In one study, a square meter of leaf litter turned up 50 species of ants alone.

CHARLES L. HOGUE

Because most tropical forest soils are poor, farmers burn the cleared vegetation and improve the soil with nutrient-rich ash. This method of agriculture, known as slash and burn or swidden agriculture, has been practiced throughout the tropics for thousands of years. As an agricultural method it is not inherently destructive—if the land is allowed to rest for sufficient time between plantings, it can be reused.

cally feasible to concessionaires who want to turn a quick profit and who see vast expanses of available forest land.

Prospects for Sustainable Forest Management

The promise of extractive reserves is that they realize long-term economic benefits to essentially intact forest. The potential earnings compare favorably with other, more destructive uses of forested land, including cattle ranching and agriculture. Extractive reserves also provide benefits through the ecological services intact forests perform, while they preserve more biological diversity than other forms of exploitation. Nonwood products are increasingly being factored into economic equations, and new markets are being explored.

However, the low levels of exploitation that characterize extractive reserves also serve as the major limitations to their economic success. Without careful management, the harvesting techniques can be destructive and can effectively extirpate the species being exploited. For the most part, nonwood forest products are not part of the world economic trade because they are sold at local markets. If marketing is scaled up carelessly it could lead to overexploitation. In addition, there is enough forest disturbance (particularly through hunting and subsistence gardening) that even extractive reserves would not protect many forms of tropical forest wildlife. Ideally, the extraction of nonwood products works best under conditions of low population density and careful demarcation of collection areas. It is possible that a combination of careful selective logging and extraction of nonwood products might yield a maximum economic return while providing ecological services and preserving some wildlife.

Indigenous Agriculture

People have lived in tropical forests for thousands of years and over that time have developed techniques for growing food in a sustainable manner. The Indians' close ties to the land have fostered sophisticated knowledge about soil type and growing season that tribal people pass between generations. This also holds true for many nontribal people—mestizos or peasants who have lived in tropical forest areas for many generations. (The term "indigenous" in this article refers to both tribal and non-tribal people with generations of experience in forest farming.) Many groups have well-developed knowledge of agronomy and the cultivation of wild plants. Indigenous agriculture emplys a splendid diversity of crops and cropping techniques that defy easy generalization. However, the most environmentally sound and sustainable practices are those that mimic the natural ecology of a tropical forest.

CHARLES L. HOGUE

This fungus is in the genus **Cookeina.** *Fungus and microorganisms are rapid and efficient decomposers of dead animals and plant material and important recyclers of tropical forest nutrients.*

Indigenous agriculture is often characterized by the careful use of land—generally the intensive use of small plots or the longer use of larger plots. Many groups make use of tree crops or cultivate crops in a system that mimics natural forest regrowth several years after cutting: first root crops, then shrubs, and finally trees. The return of nutrients to the land is also key to many indigenous agricultural systems. This is achieved through the composting of unused plant parts, kitchen waste, and human and animal waste.

Another hallmark of indigenous systems is the diversity of crops grown. For example, one garden could contain plants for food, fiber, fodder, fuelwood, medicine, shade, support for other climbing plants, and soil conditioning through nitrogen fixation. The diversity of crops provides products year round and makes the farm plot less susceptible to spread of disease. Manual weeding and biological pest control techniques are also used extensively in indigenous systems. By intercropping, or interplanting different types of crops, productivity is increased and insect predators can be confused or repelled. Hand weeding also minimizes the soil compaction caused by use of machinery.

The Application of Sustainable Techniques

The clearing of forest land for subsistence agriculture is already one of the principal causes of tropical deforestation worldwide, and with the population of tropical countries expected to nearly double within forty years there is an urgent need for development of sound agricultural techniques. Many of the principles of indigenous agriculture could be applied to improve less sustainable subsistence agriculture.

Under a typical slash-and-burn subsistence system, a single family in the Yucatan Peninsula of Mexico clears about two hectares each year. Under the most desirable conditions, the land should rest for thirty years before it is reused, so each family requires a minimum of 60 hectares. An innovative agricultural system that involves nutrient enrichment with mulch and inexpensive watering technology can grow about the same amount of food on half the land.

As promising as new cropping methods may be, new techniques are not easily adopted. New methods must produce more food than traditional means, be easy to learn, inexpensive, and socially acceptable. For example, many of the indigenous techniques are quite labor intensive and require hand-weeding—a back-breaking chore that anyone accustomed to low-effort farming might avoid. Demonstration farms and locally run agricultural extension programs are the most effective form of introducing new methods, but these are long-term ventures, requiring patience and perseverance.

It will be no easier to convince large-scale

Insects of the rainforest are astonishingly diverse. The tail end of this sphinx caterpillar (Hemeroplanes ornatus) *mimics a poisonous snake to startle predators.*

producers to adopt indigenous techniques. The careful, labor-intensive use of land and other principles of sustainable subsistence agriculture are antithetical to large scale agribusiness. Certain small-scale cash crop producers use tree crops and enrich the soil with natural materials, but most large-scale production of cash crops is oriented toward export and garnering foreign currency. This most often means that producers grow only one crop and rely upon using machinery and inputs such as fertilizers and pesticides.

Debt for Nature

The need to service overwhelming debts can drive tropical countries to exploit every available natural resource and make forest conservation an expensive luxury. The developed world cannot expect tropical countries to foot the entire bill for tropical forest conservation. Many types of innovative funding schemes have been proposed, and debt-for-nature is just one example. The brillance of debt-for-nature swaps, or debt exchanges, is that they recognize the economic bind crippling even the most well-intentioned of tropical countries and directly relate a major underlying cause of deforestation to a practical solution. Swaps have led to a fascinating and fruitful collaboration between economists and environmentalists. To date, nearly $100 million have been parlayed into parks, environmental education, research, and training programs.

Debt-for-nature swaps work on the principle that much developing country debt is essentially uncollectible. Lenders are willing to sell this high-risk debt at a discount price, usually between ten to fifty cents on the dollar, to recover some value, and this has led to a "secondary" debt market. In a debt-for-nature swap, debt is purchased at a discount in exchange for a commitment by a tropical country government to support conservation programs or provide local currency investments in national conservation groups. In the first swap, Conservation International, a Washington, D.C.-based environmental group, purchased $650,000 worth of Bolivian debt at 15 cents on the dollar. In exchange, the Bolivian government agreed to increase legal protection of a tropical forest reserve of 3.7 million acres and to establish a $250,000 fund for local management of the reserve. Other swaps have accepted local currency bonds from the central bank, with a guaranteed annual income that support conservation groups and protected areas.

Potential and Limits

Debt swaps have received a lot of media attention and many conservation organizations focusing on the tropical world are actively negotiating or considering debt for nature. In addition, new legislation and regulations will allow U.S. government agencies to support debt swaps and engage the multilateral development banks in the process. The programs have increased in size and spread to Africa.

The future of the debt market is uncertain, however, and many analysts predict that within ten years debt for nature will not be financially feasible. This is because the collectibility of the remaining debt becomes greater as a portion of a country's debt burden is retired. High rates of inflation, coupled with the complicated nature of arrangements for debt exchanges, make them less attractive if the discount is not high. With the exception of the Philippines, debt exchanges are not seen as an option in Asia. There is virtually no market for Asian debt because Asian countries are for the most part current on their debt payments.

The Need for Diversity

We are still learning how to preserve tropical forest effectively or use it wisely, although there is little time left to perfect techniques. Today there is only slightly over half the original forest intact, and half of these may be lost by 2035. Given the diversity of forest types and diversity of development pressures on tropical forests, we will need to employ a diversity of techniques to save forests. Just as one new agricultural technique or miracle crop will be unsuitable in certain areas, there will be no single big idea, technological fix, nor economic incentive that will solve the problems of tropical deforestation. Instead, it will require a diverse array of techniques simultaneously applied at the local, regional, national, and international levels to slow or halt the spiraling loss of tropical forest.

Judith Gradwohl is the Director of the Office of Environmental Awareness at the Smithsonian Institution. She is curator of the traveling exhibition, Tropical Rainforests: A Disappearing Treasure, *and an author of the book,* Saving the Tropical Forests.

GEORGE D. DODGE, KATHLEEN M. DODGE, AND DALE R. THOMPSON

RAINFORESTS
The Hawaiian Perspective

by ROBERT GUSTAFSON

R. GUSTAFSON

Palms are common rainforest plants in other regions of the world, but not so in Hawaii.* Pritchardia *is Hawaii's only native palm genus.* Pritchardia beccariana, *the tallest of the native palms, is pictured here with* Metrosideros polymorpha *from Kulani Road, Hawaii.

The Hawaiian Islands lie isolated in the mid-Pacific approximately 2,500 miles from the nearest continental land mass. The archipelago extends from Kure and Midway atolls to the big island of Hawaii, a distance of almost 1,600 miles. The islands and seamounts of the Hawaiian chain and its northwest continuation, known as the Emperor Seamount chain, march across the Pacific some 3,600 miles and terminate near the Kamchatka peninsula in Asia. The oldest Emperor seamount (a former island that has submerged below sea level) is estimated to have an age of 70 million years, while the youngest island, Hawaii, is less than a million.

The islands are actually the tops of giant volcanoes that arise from the depths of the ocean floor. Mauna Kea on Hawaii is the highest point in the Pacific, looming about 14,000 feet above sea level. Mauna Kea and the other volcanoes were formed when the magma rose to the surface at a localized region in the earth's mantle called a "hot spot." The hot spot responsible for the Hawaiian-Emperor chain has occupied its present position for about 70 million years. The move-

ment of the Pacific plate in a northerly direction occurred about 42 million years ago. Even today a new island, Loihi, is forming at 3,000 feet below sea level about 30 miles southeast of Hawaii. Tens of thousands of years from now it will rise above the surface of the ocean just like its predecessors. Once volcanism has subsided, erosion sculpts and shapes an island. Rainfall and the action of the sea continually wear away the lava, reshaping the contours of the land. It is these forces that have created the many valleys and ridges so prevalent in the islands today.

Many factors contribute to the wide variety of habitats found in Hawaii. Among them are an equable climate with mild temperatures the year round; high mountains, which have a profound effect on local weather patterns, especially rainfall; and prevailing trade winds. Furthermore, the landscape is so varied that microclimates are abundant, creating sharp contrasts from one locality to another, often within short distances.

There are five major plant communities in Hawaii: coastal, lowland, montane, subalpine, and alpine. Rainfall within these zones is designated as *dry* (less than fifty inches a year), *mesic* (between fifty and one hundred inches) and *wet* (over one hundred inches). Hawaiian rainforests are found within the lowland and montane zones. The term "wet forest" has been used by Hawaiian ecologists in place of "rainforest." By comparison with a Central American or Malaysian rainforest, the wet forests of Hawaii lack the species diversity of the others both in fauna and flora. Also the forest canopy is seldom over one hundred feet above the ground, unlike continental tropical rainforests, which often exceed three hundred feet.

It is likely that coastal and dry forest areas were probably the site of most of the colonizations of plant and animal groups. Their subsequent diversification into wetter areas indicates an ecological shift. Seeds of plants that disperse readily usually belong to nonwoody plant groups and are well adapted to growing in open or disturbed places. Seeds of forest trees tend to be large and for the most part are not well adapted to long-distance dispersal. The Hawaiian Islands have abundant rainfall and high humidity–an excellent environment for the development of forest trees. Wet forest plants are woody and the shift of plants into the wet forest would involve increased woodiness. Rosette trees and shrubs are common in Hawaii. In these plants the leaves are clustered at the end of a branch or branches (sometimes there is only one main stem). They seem to be derived from rosette herbs (like that of a cabbage). The Hawaiian lobeloids are good examples. Because the moderate climate promotes a continuous growing season, the Hawaiian flora is almost exclusively perennial with no true annuals (except possibly *Nama*) and a few biennials. It is interesting to note that the wet forest elements are predominantly Indo-Malaysian in origin.

The ohia *(Metrosideros polymorpha)* is the dominant forest tree, sometimes exceeding 120 feet. Wet ohia forests can be found in all stages of development in Hawaii depending on the nature, age, and climate of the lava flows on which they grow. The understory is largely dominated by the hapu'u ferns of the genus *Cibotium* along with shade-tolerant shrubs and other native ferns. On open, disturbed areas, recent lava flows and on steep ridges the uluhe fern *(Dicranopteris linearis)* often forms impenetrable tangles.

Several endemic Hawaiian genera of plants are inhabitants of the wet forest: *Broussaisia*, a hydrangea relative; *Touchardia*, a member of the nettle family, highly prized by the Hawaiians for its tough fiber; *Hillebrandia*, a monotypic member of the begonia family; most of the baccate or fleshy fruited lobeloids, *Cyanea*, *Clermontia*, and *Rollandia*;

R. GUSTAFSON

Wet forest, Kamakou Preserve, Molokai. Hawaiian ecologists use the term "wet forest" rather than "rainforest." Hawaii's wet forests do not boast the species diversity of Central American or Malaysian rainforests; the forest canopy is also seldom over 100 feet. The canopy of continental rainforests often exceeds 300 feet.

Hawaii also boasts a very diverse group of insects, and among these the genus **Drosophila** *is exceptional: more than 370 species have been described and scores more await classification.* **Drosophila grimshawi** *and* **D. pullipes** *(dark legs) are seen here feeding on a* **Clermontia** *fruit.*

WILLIAM MULL

Forty-one species of the native Hawaiian land snail **(Achatinella)** *occur on the island of Oahu. They live in isolated valleys and gulches and migrate slowly or not at all. Unfortunately, more than half of those species are now extinct due to overcollecting and the introduction of a carnivorous snail. The snail seen here is* **Achatinella lila (achatinella** *means little agate) and was photographed on Kipapa Ridge in Oahu.*

WILLIAM MULL

and *Labordia*, a member of the strychnine family. *Trematolobelia*, another lobeloid with unique dispersal mechanism, grows exclusively in very wet areas. Many of the sixty or so species of *Pelea*, an almost endemic genus named in honor of the fire goddess Pele, and most of the fifty-two species of *Cyrtandra*, a relative of the African violet, are wet forest plants. The giant ape'ape, *Gunnera sandwicensis*, is a plant of shady wet gulches or cliff faces in the cloud forest. Plants in the genus *Gunnera* have a symbiotic relationship with blue-green algae, which fix nitrogen and supply nitrates to the plant. These plants grow in extremely wet, nitrogen-poor soil. Orchids, which are so prolific in rainforests in other areas of the world, are practically absent from Hawaii. There are only three endemic species. One reason why orchids as a group never became established in Hawaii is the probable lack of suitable pollinators.

Most people familiar with garden lobelias would hardly recognize their Hawaiian counterparts. Here the plants range in size from rosette perennials a foot high to small trees twenty feet tall. The flowers exhibit a vast array of colors. The various lobeloid genera underwent a long period of interrelationship with the many genera and species of the endemic Hawaiian honeycreepers. The curved lobelia flowers and the curved bills of the birds are closely linked. Not all of the honeycreepers are nectar-feeders, but those that are (or were) have a specific relationship with particular lobeloids. The plants, however, are not solely dependent on the birds for pollination. This function is largely performed by insects today.

Most of the fifty-two species of *Cyanea*, eight species of *Rollandia*, and all twenty-two species of *Clermontia* are inhabitants of the wet forests. Some of these plants are fairly common such as *Clermontia parviflora* on Hawaii while others, like *Cyanea aculeatiflora*, are rare, preferring wet shady gulches on East Maui. Other common wet forest plants include the olapa *(Cheirodendron)*, kopiko *(Psychotria)*, pilo *(Coprosma)*, hame *(Antidesma)*, kawa'u *(Ilex)*, kolea *(Myrsine)*, ma'nano *(Hedyotis)*, and mamaki *(Pipturus)*.

The wet forest is quite rich in fern species. The hapu'u *(Cibotium)*, the ama'u *(Sadleria)*, and the tongue ferns *(Elaphoglossum)* are common components of the wet forest. Epiphytes (ferns, mosses, liverworts, and lichens) are abundant especially in areas with high rainfall and often completely cover branches and trunks of trees. Bromeliads, common epiphytic plants of the new world tropics, never reached Hawaii. Nor did the aroids (such as *Philodendron* and *Anthurium)*, which are widely distributed thoughout old and new world rainforests. Some native Hawaiian flowering plants, such as *Astelia* and *Peperomia*, are commonly encountered as epiphytes. The ie'ie *(Freycinetia arborea)* sometimes acts like an epiphyte, but is really more of a climber. Its bright orange bracts, which subtend the flowers, stand out like beacons in the forest canopy. The only native palm genus, *Pritchardia*, is represented by a number of species. Palms are common rainforest plants in other regions of the world, but not so in Hawaii. Even the ubiquitous coconut palm, *Cocus nucifera*, is thought to be a Polynesian introduction.

The Hawaiian honeycreepers are a very unique and specialized group of birds that are endemic to the Hawaiian Islands. They have achieved a remarkable degree of diversification not only in the number of recognized genera and species but also in the shapes and sizes of their bills. What is even more remarkable is that they have evolved from a common finch-like ancestor. They are often cited as an outstanding example of the principle of adaptive radiation. Simply defined, this concept connotes the entry and diversification of a group, whether plants or animals, into a variety of habitats available for colo-

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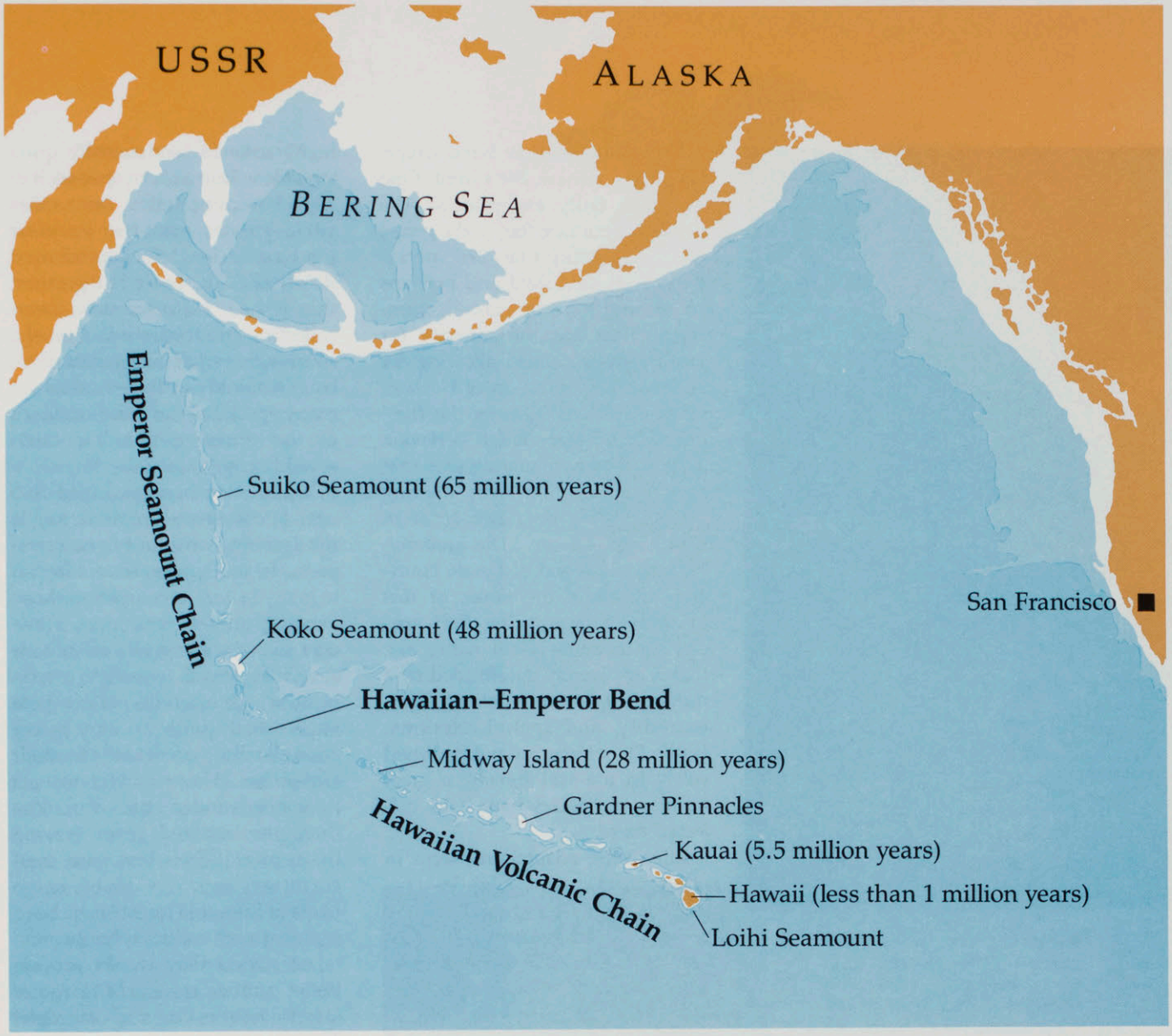

The Hawaiian Volcanic and Emperor Seamount Chains

nization. Islands or archipelagos are good places to observe adaptive radiation because of their discrete size. Populations become isolated on islands within an archipelago and often on the islands themselves, allowing repeated opportunities for speciation.

The wet forest is home to many of these birds. Some, like the brightly colored i'iwi *(Vestiaria coccinea)* and apapane *(Himatione sanguinea)*, are still fairly common. Others, like the crested honeycreeper *(Palmeria dolei)*, are rare and seldom seen. Because of the specialization that has evolved in this group of birds, diets often differ from one species to another in the same genus. Some are solely nectar feeders while others are insectivorous, granivorous, frugivorous, or combinations of the above. Other land bird groups that colonized the islands include a monarch flycatcher, an old world warbler, a hawk, an owl, and a crow. The arrival of the birds, like that of the plants, was accomplished by long-distance dispersal. Although the mode of origin for plants can be accounted for in different ways, the land birds were probably blown off course during freak storms. Their advent and establishment in Hawaii were purely matters of chance. The o'os *(Moho)* are represented by four species and are notable because the tufts of yellow feathers near their wings were used by the Hawaiians in their famous feather capes. The only extant species, *Moho braccatus* from Kauai, had dwindled to only one or two individuals in the remote forests of the Alakai Swamp. It may now have joined the long list of extinctions of native birds. Shore birds such as the golden plover regularly visit the islands and undoubtedly have been important in the dispersal of plants. Even migratory waterfowl have been successful colonizers on a few occasions. Hawaii's most famous bird, the nene or Hawaiian goose *(Nesochen sandwicensis)*, has adapted to a nonaquatic life in the subalpine regions of Hawaii and Maui.

R. GUSTAFSON

Metrosideros polymorpha, ***the ohia, is the most ubiquitous and variable plant in the Hawaiian Islands. It is the dominant tree of the wet forest.***

Hawaiian insects have diversified to a remarkable extent. One group is truly exceptional: the Hawaiian pomace flies of the genus *Drosophila*. More than 370 species have been described and perhaps scores more await classification. This genus has the capacity for rapid genetic change allowing for successful colonization of Hawaii's diverse habitats. One of the flies' outstanding traits is lek behavior. That is, they have mating sites that are different from their feeding localities. This does not occur in continental species. The anatomical structures and elaborate courtship rituals of the males of this group are truly amazing. Each species has its own special mating site that is apparently determined by a number of factors such as light, humidity, and spatial relations. While *Drosophilas* are not confined solely to the wet forests, a great number of species have been collected there.

Interesting adaptations occur in other insect groups: flightlessness in Hawaiian lacewings, beetles, crickets, and grasshoppers; carnivory in the larva of the geometrid moth *Eupithecia;* plant host specificity in the longhorn beetle *Plagithmysus;* gigantism in the dragonfly *Anax strenuus* and the Nihoa grasshopper *Banza nihoa*. These are but a few examples.

Another remarkable group of organisms are the endemic land snails, particularly the Achatinellids. *Achatinella* (which means little agate) is restricted to Oahu and widely dispersed in the Koolaus, the wetter of the islands' two mountain ranges. The genus also occurs in the Waianae Mountains. Because the Koolau Mountains have many isolated valleys and gulches, most of the forty-one known species occur there (although more than half of them are already extinct). The colonies migrate slowly or not at all. In fact, a single individual may remain on a tree or shrub its entire life, grazing on fungi and algae present on the leaves. The shells of this genus are highly colorful and usually quite variable within a given species. Perhaps less competition from other snail groups and the peculiar topography of Oahu has allowed *Achatinella* to speciate to the extent that it has. Unfortunately, overcollecting and the introduction of a carnivorous snail, *Euglandina rosea,* have resulted in the extinction of many species. In fact, the existence of the entire genus has been severely compromised.

It has often been assumed that island ecosystems are more fragile than their continental counterparts. Island species have adapted to many factors as complex as those existing on the mainland. However, introduced species often pose a serious threat to native organisms, which often do not compete successfully with an aggressive alien–leading eventually to their extinction. Hawaii's wet forests have been under attack for more than one hundred years, leaving the future of their biological treasures very much in doubt. Large tracts of Koa-ohia forests have been replaced with exotics with the mistaken notion they would provide better timber resources. Firetree *(Myrica faya)* is one such example. This fast-growing native of the Azores has naturalized in many areas, particularly in and around Hawaii Volcanoes National Park. Once the plants have become established, they are truly insidious in that practically nothing grows beneath them. Other examples of introduced plants that thrive in wet forests and are now regarded as serious pests are banana-poka *(Passiflora mollissima),* Coster's Curse *(Clidemia hirta),* strawberry guava *(Psidium cattleianum),* and Kahili ginger *(Hedychium gardnerianum).*

Feral pigs abound in wet forest areas. Their destructive habit of rooting and digging paves the way for the introduction of such alien plant species as those mentioned above. They also pose a big threat to certain kinds of native plants for which they have a decided prefer-

ence. *Cibotium* and *Marattia* ferns, the native lobeloids, and some species of the araliad genus *Tetraplasanda* are just a few examples. Pig populations are maintained for hunting, so their elimination in sensitive areas poses a real management challenge.

Geothermal wells have been proposed in areas of forest just outside the boundaries of Hawaii Volcanoes National Park. Needless to say the impact of such activity would be dramatic. Logging and subsequent conversion of forest lands to pastures has already severely depleted large tracts of wet koa-ohia communities.

The litany of ecological disasters that has besieged Hawaii since the advent of the first Polynesians more than 1,500 years ago has been in many ways catastrophic for both the fauna and flora. What has been lost cannot be replaced. Yet there is still much to protect and preserve. Several plant species thought to have been extinct have been rediscovered in recent years. In 1973 a new genus of honeycreeper *(Melamprosops)* was found in the remote forests on the northeast slopes of Haleakala on East Maui. Fortunately, conservation efforts and the realization of the unique character of the islands' natural history are gathering momentum. The Nature Conservancy has already purchased several tracts of critical habitat and targeted many more. Only when international conservation efforts focus in the direction of Hawaii will the battle to save some of the most unusual life forms on earth seem more secure.

Robert Gustafson is the collections manager for the botany section of the museum. He has been studying and photographing the native Hawaiian flora since the mid-seventies and is co-author of the Plants and Flowers of Hawaii. *His photographic exhibit* ***Hawaii's Unique and Vanishing Flora*** *is one of this museum's traveling shows currently on view in the eastern United States.*

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The akohekohe or crested honeycreeper* (Palmeria dolei) *is a very rare bird from the forests of East Maui that feeds largely on the nectar from ohia blossoms.

GUSTAFSON

Cyanea aculeatiflora ***is a rare lobeloid found in wet, shady gulches on East Maui.***

L. A.'S THE PLACE FOR BIOLOGICAL

How a Little Lady Beetle Saved California's Citrus Industry

by JOEL GROSSMAN
Photographs by
Ron West

Southern California and trend setting became synonymous in 1888–1889 when Los Angeles citrus ranchers demonstrated to the world that beneficial insects controlled exotic pests better than pesticides (in those days, cyanide gas was pumped under tents covering the trees). The beneficial insect heroine was a chunky red and black Australian lady beetle, the Vedalia, aided and abetted by a cast of human characters whose soap opera antics included bamboozling the U.S. Congress to achieve biological control of the cottony-cushion scale.

The cottony-cushion scale, an Australian insect that settles down like a barnacle beneath a waxy white covering and spends its life sucking plant juices, found 1880s California to be the promised land. The scale is rarely seen in its native Australia because it is under the control of predators and parasites. Liberated from its natural enemies in the favorable California climate, the scale exploded to pest status.

Local citrus growers, unable to control the scale, began ripping out and burning those picture-post-card-perfect orange trees growing against a backdrop of snow-capped mountains. Property values plummeted, and ranchers were ready to listen to any solution, no matter how far-fetched.

Charles Valentine Riley, the U.S. Department of Agriculture's chief entomologist in the 1880s, found California citrus growers a receptive audience for a controversial theory known as biological control. In classical biological control, the homeland of an exotic pest is searched for natural enemies that are imported to provide pest control. The underlying belief is that newly arrived animals and plants (weeds) explode to pest levels in new lands (providing climate and ecological conditions are ideal) when the predators and parasites providing natural pest control are left behind.

Classical biological control reestablishes the ecological balance by bringing the natural enemies to the new land. As invited speaker at the April 1887, California Fruit Growers' Convention in Riverside, Riley recommended searching cottony-cushion scale's native homeland for natural enemies to bring to California. Cottony-cushion scale migrated to California from Australia via Europe (having been originally collected and described on plant specimens from Australia's Botany Bay by Captain James Cook in 1769).

Riley told the California growers that the U.S. Congress would laugh at the idea of sending an entomologist to Australia to collect beneficial insects. "The mere suggestion that I wanted $1,500 or $2,000 for such a purpose would be more apt to cause laughter and ridicule on the part of the average Congress than serious and earnest consideration," said Riley. Left unmentioned was the fact that Congress had prohibited Department of Agriculture foreign travel in order to stop Riley's frequent European junkets.

Riley urged the growers to ask the state of California and Los Angeles County for a few thousand dollars for the mission. The California Fruit Growers' Convention voted in favor of the idea. The state of California then asked the federal government to appropriate money to send an entomologist to Australia and was turned down.

No one wanted to risk funding this innovative venture. At the same time, however, the orchardists who needed the help had enough money to offer rewards of up to $10,000 for the invention of remedies that would wipe out the scale pest. No cure-alls captured the reward money. The ranchers, who wanted only government money spent on biological control of their pest problem, would have been out of the citrus business were it not for Riley's political acumen.

Riley was known in Washington for bypassing his superiors and bureaucratic channels to solicit congressmen personally for pay raises and appropriations. When it became known that the State Department had set aside funds to send personnel to Australia for the Melbourne Exposition, Riley's ability to manipulate the political system paid off. With the cooperation of Frank McCoppin of San Francisco, U.S. commissioner to the exposition, $2,000 was set aside to pay the travel expenses for one of Riley's entomologists (ostensibly in Australia to report to the State Department on agricultural exhibits) to collect beneficial insects.

The Department of Agriculture entomologist hidden on the State Department expense account was Albert Koebele, an accomplished insect collector who first caught Riley's eye at the Brooklyn Entomological Society with his beautiful technique for mounting insect specimens. Koebele was in the right place at the right time—California—because it was as far west as he could go to get away from an unhappy love affair.

Riley instructed Koebele to bring back a parasitic fly, *Cryptochaetum iceryae*, which attacked cottony-cushion scale. Australian entomologist

Frazer Crawford had brought the fly to Riley's attention, suggested its use in California, and sent live flies to San Francisco Bay area counties for release in 1887. The flies were established in San Mateo County prior to Koebele's voyage and are still effective natural enemies, though not capturing the public imagination like the Vedalia beetle.

Koebele searched Australia for almost two weeks in late 1888, finding nary a trace of the scale and its natural enemies until Crawford came to his aid. Biological control of cottony-cushion scale by natural enemies was so good that local farmers and other entomologists were not even aware that the pest existed. In the first garden searched in Adelaide, however, Crawford led Koebele to cottony-cushion scales parasitized by the fly *Cryptochaetum*. In the years that followed, Crawford was among the many unhappy people who later felt slighted by a California press that ignored their contributions and played up the local boys.

Koebele was in Australia almost a month when, while collecting with Crawford in North Adelaide, he spotted a Vedalia beetle feeding on a fat female cottony-cushion scale. Koebele packed five shipments of Vedalia beetles, parasitic flies and green lacewings on ice for the month-long steamer voyage from Australia to California. Being cold-blooded animals, insects can be kept alive packed in ice, but a gale throwing cakes of ice crushed the San Francisco-bound insect cargo. On the four Los Angeles-bound shipments, only 164 Vedalia beetles survived.

On his way home in early 1889, Koebele, following orders from his boss, Riley, stopped in New Zealand, which was having its own cottony-cushion scale outbreak. R. A. Wight, an orchardist and amateur entomologist, directed Koebele to New Zealand's Napier (Hawke's Bay) fruit-growing area, which yielded 6,000 more Vedalia beetles. Later in 1889 Wight wrote, "He [Koebele] collected thousands of them, and, delighted with his success, telegraphed at once to California to stop all cutting down of trees." Of the Vedalia beetles collected in New Zealand, 350 survived the icy journey to Los Angeles in the company of Koebele.

As the Vedalias arrived in Los Angeles, Koebele's co-worker, Daniel W. Coquillet, placed the first three shipments of 129 beneficial beetles on scale-infested orange trees at the J. W. Wolfskill Ranch near what is now Union Station in downtown Los Angeles. A fourth shipment of thirty-five Vedalia went to the J. R. Dobbins ranch in San Gabriel. The last shipment of 350 Vedalias from New Zealand was divided, with a third going to the Dobbins ranch and the rest going to the A. Scott Chapman grove in the San Gabriel Valley.

Coquillet, who came to Anaheim to recover from tuberculosis, turned the trees into giant insect-rearing cages by covering them with fabric tents. Few of the 12,000 imported *Cryptochaetum* flies survived on the Wolfskill insectary tree (though the fly is established as a biological control agent along the coast), but the Vedalia population under the tent exploded, decimating the scale pest.

Insect Zoo Preview

The Insect Zoo preview, located in the Ralph M. Parsons Discovery Center for Children, is your chance to see many different kinds of these fascinating creatures up close. Come and see giant desert millipedes, centipedes, black widows, tarantulas, scorpions, darkling beetles, and giant hissing cockroaches. As an added bonus, an Insect Zoo staff member will be on hand Saturdays to talk about the animals on display and answer all of your insect questions. The permanent exhibit, **Through the Insect Realm,** has been generously supported by the Ralph M. Parsons Foundation and will be opening in 1991.

The tent over the insectary tree was opened, allowing beneficial beetles to spread to neighboring trees at the Wolfskill ranch. Within a few months Vedalia beetles completely cleaned up the cottony-cushion scale problem. In the spring of 1889, 10,555 Vedalias from the Wolfskill ranch were distributed to 208 citrus growers who experienced the same miraculous pest control success that led William F. Channing of Pasadena to say, "The deliverance was more like a miracle than anything I have ever seen."

In July 1889, J. R. Dobbins of San Gabriel, who started with 150 Vedalia in his orchard earlier in the year, stated that

> "the vedalia has multiplied in numbers and spread so rapidly that every one of my 3,200 orchard trees is literally swarming

Continued on p. 42

Vedalia beetle on lemon blossom

VEDALIA BEETLE

(Rodolia (Vedalia) cardinalis). Female beetles are reddish, males are predominantly black, although a dense covering of hairs sometimes obscures the coloring, giving the insects a grayish appearance. Female Vedalias lay red oval eggs singly or in small clusters on egg sacs of cottony-cushion scale. One female beetle can lay up to 1,000 eggs, though 150 to 300 is average. Eggs hatch in two to nine days. The alligator-shape beetle larvae vary in color from dark orange-red to pinkish. They have black markings and prey on young scales and scale eggs.

When full grown, the larvae become two-tenths to three-tenths of an inch in length and pupate on the leaves, branches, or bark of trees. The pupa is covered by the old larval skin and is whiteish with black dots. In about a week the mature adult beetle emerges from the pupal stage and almost immediately begins to eat—and mate (male beetles have been known to rip the covering off female pupae and begain mating before the female has emerged; the female starts her life-long egg laying the next day). Adult Vedalia beetles eat mature scales as well as younger scales and scale eggs. Vedalias go from egg to adult in sixteen days during warm weather, but take as long as three months in cooler weather (insects are cold-blooded animals and depend on warmth from the sun to develop).

One reason Vedalia beetles are such effective biocontrol agents is that they produce two to two and one-half generations for every one generation of the pest. As many as a dozen generations of Vedalias in a year have been reported. The beetle survives cold winters by finding warm overwintering locations (for example, in infested shrubs or near dwellings). Vedalias are easy to raise—put a citrus cutting infested with cottony cushion scale so that the cut stem is partially in water, enclose in a muslin cloth, and introduce a female Vedalia beetle. Only four Vedalias were introduced into Peru, and they colonized that country's citrus plants.

Cottony-cushion scale

COTTONY-CUSHION SCALE

(Icerya purchasi), an Australian native, was introduced into California via acacia plants sent to a Menlo Park nursery in 1868 or 1869. Scale host plants include citrus and many other fruit and nut trees, acacia, amaranthus, castor bean, chenopodium, fig, grape, locust, magnolia, nettle, pepper, purslane, polygonum, potato, rose, geranium, spearmint, sweet gum, verbana, and veronica. Scales cause damage to plants by extracting plant sap, which reduces tree vitality and causes defoliation and fruit drop. A black sooty mold fungus grows on honeydew excreted by the insects, making a mess of the fruit and foliage.

The scale is named after its cottony white fluted egg sac, upon which Vedalia beetles lay their eggs. Each egg sac contains 600 to 1,000 bright red eggs. Eggs hatch in a few days during hot summer weather, but take as long as two months to hatch in winter.

Newly hatched nymphs are bright red and feed along leaf veins and midribs. By the third instar (an instar is a stage in an insect's life between two successive molts), scales move to the twigs and eventually settle down on the tree trunk and larger branches. The red-brown oval body of the insect then becomes obscured by cottony wax. After the third molt the scale reaches the sessile (or sedentary) fourth instar and frees itself of its waxy covering. The red-brown color of the scale becomes apparent in this late stage of the life cycle, and the egg sac begins to form. Male scales are frequently overlooked because they are thinner and form a cocoon in concealed spots on the tree or on the ground before becoming two-winged adults. Entomologists believe that male cottony-cushion scales are superfluous–mature female scales are hermaphroditic, reproducing without males.

Continued from p. 39

Ants tending cottony-cushion scales for the honeydew they produce

> with them. All of my ornamental trees, shrubs, and vines which were infested with white scale, are practically cleansed with this wonderful parasite, ...People are coming here daily, and by placing infested branches on the ground beneath my trees for two hours, can secure colonies of thousands of the vedalia, which are there in countless numbers seeking food. Over 50,000 have been taken away to other orchards during the past week, and there are millions still remaining, and I have distributed a total of 63,000 since June 1."

By the end of July, however, Dobbins posted a notice that he had no more beetles to distribute.

The story was similar at the 150-acre Chapman orchard, and Los Angeles County orange shipments nearly tripled from 700 to 2,000 carload lots in one year. Total cost of the biological control project was less than $5,000. As with most successful biological control programs, benefits of millions of dollars per year are still accruing annually in California citrus groves.

Years later, entomologist, L. O. Howard summed up the beneficial insect hysteria that swept California, writing in a Smithsonian Institution report that "the state went wild on the subject of bringing over beneficial insects from Australia."

In 1989 a Vedalia Conference was held at the University of California, Riverside, which continues to search for biological control solutions to southern California's pest problems. This centennial celebration reviewed hundreds of biological control successes around the world inspired by the Vedalia. At the conference New Zealanders reminded participants that they helped, too. In an 1889 letter Wight said, "Probably in their (California) indifference to so small a Colony as New Zealand, they class all these islands as 'Australia,' and so long as they have attained the benefit of the importation, care little to what country it is due."

Riley, who masterminded the Vedalia operation, was similarly upset at being ignored by the California press. In 1893, a year before his death in a bicycle accident, Riley recalled his employees from California in protest.

The Vedalia success led the state of California to appropriate $5,000 in expense money to send Koebele (who was still on the Department of Agriculture payroll in Washington) back to the South Pacific in search of more beneficial insects in 1891. Koebele collected additional Vedalia to save South Africa's citrus, as well as another lady beetle, the mealybug destroyer, *Cryptolaemus montrouzieri*. The mealybug destroyer, which was raised at a branch insectary in Alhambra, is still released annually in Ventura County orchards and sold mail order for use on houseplants and interior plantscapes.

For his efforts, the Fruit Growers' Association of California awarded a gold watch and his wife a pair of diamond earrings. In writing Koebele's obituary in 1925, L. O. Howard said, "I imagine that this presentation of diamond earrings to the wife of an entomologist as the result of his own work in entomology is probably unique. I happen to know of no other entomologist who has been able to see that his wife wears diamond earrings!"

Koebele moved on to a higher paying job with the government of Hawaii in 1893 and imported beneficial insects from Mexico to control sugar cane pests and weeds. After moving back to his land of birth, Germany, from were he made excursions to collect fly predators and parasites

for Hawaii, Koebele's health and eyes failed. The Germans called the collection of beneficial insects for pest control the Koebele method in his honor.

Koebele's efforts to save the California orange industry carried little weight with U.S. immigration authorities, however. In 1921, Koebele, a naturalized citizen of the United States who was experiencing hard times, was denied permission to reenter the United States. This sad state of affairs led Mr. E. K. Taylor, Koebele's friend and former Mayor of Alameda, to say, "I feel ashamed to eat another orange."

Los Angeles continued pursuing biological control. The Annual Report of the Agricultural Commissioner for the County of Los Angeles for 1929 indicated 103 insectary employees distributing more than six million lady beetles for mealybug control on 1,067 citrus ranches covering 11,043 acres. There was a beneficial insect lab in Downey, and a house was remodeled into the Melrose-Highlands laboratory and insectary.

While the Los Angeles insectaries are now long gone—as is most of the citrus, having been replaced by urban development—nearby Ventura County still maintains insectaries raising beneficial insects for citrus growers. The most notable is the Fillmore Insectary, a cooperative established by Howard Lorbeer in 1926. Many of the approximately 10,000 acres in the Fillmore district go decades without pesticide sprays. Among the beneficial organisms used are decollate snails to control brown garden snails, the wasp *Metaphycus helvolus* to control black scale, the wasp *Aphytis melinus* to control red scale, and *Cryptolaemus montrouzieri*, the mealybug destroyer introduced by Koebele.

A number of companies, including Rincon-Vitova Insectaries (P.O. Box 95, Oak View, CA 93022) in Ventura County, the first private-sector commercial insectary, sell these and other beneficial insect species by mail for use on farms, gardens, greenhouses and interior plantscapes (for example, in banks, hotels, and restaurants). The California Department of Food and Agriculture has published a list of about sixty companies selling beneficial organisms such as green lacewings that attack a variety of small soft-bodied pests, *Trichogramma* wasps parasitizing moth eggs, *Encarsia* wasps attacking whiteflies, fly parasites, *Bacillus thuringiensis* (BT), a bacterium killing caterpillar pests, and predatory mites that eat pest spider mites.

Vedalia with cottony-cushion scale

Predatory mites are now widely used in California strawberry fields, mainly because repeated sprayings have left pest spider mites resistant to pesticides. The beneficial mites have cut pesticide applications from fifteen per season to fewer than two in many Oxnard and Ventura strawberry fields.

Farther up the California coast in Watsonville strawberry fields, the Bug Vac (a vacuum cleaner-like suction device mounted to a tractor) continues California's innovative insect control tradition, sucking up Lygus bugs without harming the expensive beneficial predatory mites used for spider mite control. Similar vacuuming devices are being tested on other California crops, including lettuce and grapes.

Thus, one hundred years after the Vedalia beetle provided permanent biological control of the cottony-cushion scale, California continues to use biological control and be the innovator and trend setter in insect control.

Joel Grossman is a local freelance writer with a special interest in entomology.

Continued from p. 7

DON MEYER

A view of the museum's newly refurbished Pre-Columbian Hall.

STAFF PUBLICATIONS

ASSOCIATE DIRECTOR FOR PUBLIC PROGRAMS PUBLISHES GEMSTONE VOLUME. Van Nostrand Reinhold has recently published *Gemstones and Their Origins* by Dr. Peter C. Keller, the museum's Associate Director for Public Programs. The book features photographs by longtime museum friends Erica and Harold Van Pelt, world-renowned for their stunning photographs of minerals and gemstones.

The volume provides the only comprehensive coverage of the geological origins and mining of gemstones available to the general public; it includes in-depth looks at eight of the classic gem-producing areas of the world, including Sri Lanka, Australia, and Brazil. Also covered in the book are how and why gemstones grow, how they crystallize, how gems vary, and how they are mined.

Gemstones and Their Origins makes a companion volume to the museum's most recent gem gallery (see TERRA, May/June 1985). The book is available at the Museum Bookstore for $49.95. Please call the bookstore at 213/744-3434 for more information.

HISTORY CURATOR CO-AUTHORS CULTURAL DIVERSITY PUBLICATIONS. History Curator William M. Mason has co-written *Asian Americans* and *Mexican Americans: No Longer a Secret* for the national education program Immigrants All...Americans All. The experimental series is a program of the Coordinating Committee for Ellis Island Inc. and is being implemented in San Diego and Chicago during the 1989-90 school year.

PERMANENT EXHIBITS

PRE-COLUMBIAN GOLD AND BALL GAME HIGHLIGHT NEW GALLERY. Pre-Columbian gold from Peru, Panama, Colombia, and Costa Rica, and a new look at the ancient Meso-American ball game *ullamaliztli*, highlight the newly refurbished Pre-Columbian Gallery at the Natural History Museum.

Curator Charles E. Rozaire organized the hall; Exhibit Designer Jane M. Herwegh redesigned it, aided by some 50 artists, technicians, and craftspeople. A striking wall mural, painted by Robert R. Reid, of Machu Picchu, an Inka city in the upper highlands of Peru, provides the backdrop for the museum's comprehensive collection of Pre-Columbian gold. The pieces have not been on exhibit for many years due to the security challenge posed by displaying them. A generous gift from the Ethnic Arts Council of Los Angeles has allowed special cases and an alarm system to be installed to give the needed security for the valuable artifacts. Design of the cases replicates the architecture of Machu Picchu, and a video explains the art of metallurgy.

A special section of the gallery focuses on the ancient Meso-American ball game ullamaliztli. Examples of apparel and equipment are on display as well as a video that shows a recreation of what is known of the game. The ball game was very important in the ancient Indian cultures. Not only did it have religious significance but it was also used to resolve conflicts. Ball courts can still be seen at archaeological sites throughout Mexico and Central America.

The gallery covers the area from Peru to Mexico, presenting cultural patterns of the civilizations found there. It shows Central American culture from its beginnings, when Indians ceased to be nomadic hunters and developed agriculture and permanent settlements, to its near-annihilation in the early 1500s with the Spanish conquest.

AWARDS

***LIFE'S DEVICES* RECEIVES STONE PRIZE.** Duke University Professor Steven Vogel's *Life's Devices: The Physical World of Animals and Plants* (Princeton University Press, 1988) has received the Jean and Irving Stone Prize for Science Writing.

Steven Vogel, a world authority on biomechanics, has brought his and others' research to life with clear, inviting prose. According to the Stone Prize Jury, the book is the definitive introduction to the subject both for the layperson and the scientist. Because biomechanics is not a fashionable subject at present, although a fundamental one, Dr. Vogel's task was not easy, yet he accomplished it with distinction.

The Stone Prize encourages scientists to bring to general attention technically difficult subjects and to make them easily accessible to all. The $25,000 annual award was founded by Irving and Jean Stone shortly before the author's death in 1989.

DEVELOPMENT NEWS

KRESGE CHALLENGE GRANT. During the final months of 1989, the Kresge Foundation's $750,000 challenge to complete our capital campaign inspired a number of major gifts. The Times Mirror Foundation generously augmented their naming gift to the Times Mirror Hall of Native American Cultures. Trustee Robert Petersen demonstrated his commitment to the Ralph W. Schreiber Hall of Birds through a second major gift from Petersen Publishing Company. Philanthropist Brent Wallis secured a substantial three-year pledge to the Times Mirror Hall from the Wallis Foundation. Through the good offices of Trustee William Mingst and the Sprague family, the Mildred E. and Harvey S. Mudd Foundation provided a naming gift for the pueblo cliff dwelling in the Times Mirror Hall. Alliance Board member Patricia Herbert and her husband Alan made possible a Schreiber Hall gift from Financial Indemnity Company. Trustees George Caldwell, Mary Crowe, Elaine Leventhal, and Betty Reddin increased

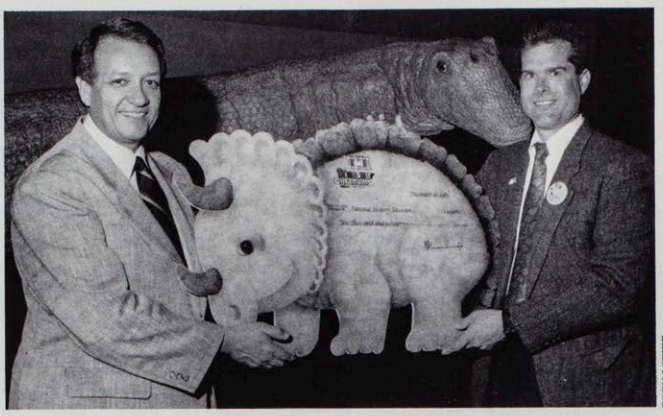
Scenes from the 1990 Members Open House.

CHRISTOPHER BARR

their prior campaign commitments to help meet the challenges. Former Alliance Board member Diana Jacobs and her husband David provided a much-appreciated gift through their family foundation.

OPEN HOUSE. All five floors of the museum were open to members on the evening of February 2 for the annual behind-the-scenes Members' Only Open House. A record 14,000 members sent RSVPs, and we estimated that nearly 6,500 actually attended. The staff was pleased by the turnout and with the opportunity to talk with our members about their collections, research, programs, and projects. Crowds gathered for photo opportunities at the History Division's trolley car and the shark jaws from the preview for the upcoming **Sharks! Fact and Fantasy** exhibition. Vertebrate Paleontology's giant crocodilian skull stopped traffic. The drawers and shelves and jars full of specimens in the Life Sciences sections attracted many visitors. Our immensely popular **Dinosaurs!** exhibition generated a long line. To all of you who perservered to experience the inner workings of your museum, thank you for visiting! And thanks also to Haagen-Dazs West, Sparkletts Drinking Water Corporation, Pepsi-Cola Los Angeles, and Mother's Cake and Cookie Company for refreshing our members.

DINOSAUR BALL. The 1990 Dinosaur Ball, chaired by Nancy and Ray McCullough, honored Mr. and Mrs. Otis Booth, Jr., for their foresight in creating a source of endowed support for museum programs. Guests danced in a tented tropical rainforest setting to the music of Les Brown and His Band of Renown and enjoyed an elegant dinner catered by Rococo. The annual black-tie fundraiser, held March 10, attracted three Discover Sponsors: George C. Page, Gumps and May Company California. Taking Diamond tables were Mr. and Mrs. Raouf Boudjakdji, Mr. and Mrs. James Stewart, Mr. and Mrs. Richard Stegemeier of Unocal Corporation, Foundations of the Milken Families, and Mr. and Mrs. H. F. Boeckmann II. Additional underwriting was provided by Mr. and Mrs. R. Stanton Avery, Mr. Ed N. Harrison, and Mr. and Mrs. Thomas Reddin. These leadership contributions, with other proceeds from the Dinosaur Ball, will support the museum's programs throughout 1990.



DICK MEIER

Rich Bailey, Product Manager for Mother's Cake and Cookie Company, presents a* Triceratops*-shaped check to Mark A. Rodriguez, the museum's Chief Deputy Director, in support of the museum's Dinosaurs! exhibition.

UNDERWRITING AND PROMOTION. The Confidence Foundation has made a generous gift in support of education programs at the museum.

Dinosaurs!–underwritten in part by Occidental Petroleum Corporation with additional support from California Partnerships and Kajima International–has been promoted by Jack In The Box, which provided colorful tray liners and discount coupons to attract visitors to the roaring, stomping exhibition of animated creatures from Kokoro Ltd. Hughes Markets featured the exhibition on shopping bags and KIIS FM sent its prize van out on December 17. Mother's Cookies donated Dinogrrrahams for the **Dinosaurs!** opening, Open House, and for giveaways on weekends throughout the exhibit. Mammoet Western Inc. trucked the monsters to the museum by way of the Los Angeles freeways during the morning rush hour, creating a flurry of press coverage for the December 12 "Dinolert" as the rubbery ancient reptilians arrived for installation.

Trustee Millicent Boudjakdji guided staff through the grant request process of the Heart Foundation, Inc., which has established the William Randolph Hearst Education Endowment with a substantial gift. The foundation's interest in the long-term good of the museum's educational mission was accompanied by support for annual operations. David and Diana Jacobs are providing substantial support to the Young Scholars program, a museum effort to identify and encourage high school students with an interest in the sciences.

The Michael J. Connell Foundation has made a generous gift to the museum's education outreach programs. Chevron U.S.A. joins the John D. and Catherine T. MacArthur Foundation in underwriting education programs for the Tropical Rainforest exhibition and JCPenney provides underwriting for the exhibition itself.

FELLOWS. An action-packed Fellows calendar has inspired new friends to join the museum's highest-level support group. We welcome Pamela Astleford, Tim Ayres, Mary L.F. Bassel, Mr. and Mrs. Paul Brounstein, Dr. and Mrs. George Chumo, Deedre and Robert Ciancio, Mrs. Donald E. Dickerson, Gerri and Robert Dickinson, Mark R. Dickson, William W. Drewry III, Mr. and Mrs. Richard L. Fruin, Jr., Drs. L. Thomas and Carolyn C. Garbriel, Daniel P. Garcia, Christina Graham, Robert and Betty Irvin, Alice Bonzi Lawler, Robert and Linda Mollno, Curley Nobles, Mrs. Milton Rubini, Paul J. and Sandra A. Russell, W.R. and Nancy Scarbrough, Laura J. Soloff, Mr. and Mrs. Alan G. Stanford, Mr. and Mrs. William E. Tatum, Mr. and Mrs. Arnold Travis, and M. Jan Watson, all of whom will enjoy a full year of Fellows adventures. For information on joining the Fellows program, please call the Development Office at 213/744-3307.

BUSINESS ASSOCIATES. Mechanics National Bank, McBain, Rose Partners, California Korea Bank, and Unocal have joined the museum's corporate support group. The Business Associates provide unrestricted support, which serves as the foundation for our fine museum programs.

The museum is available to our Corporate Sponsors (donors of $5,000 or more) for special events. Among those who have used this benefit support are Chase Manhattan, JCPenney, Chiat Day, and Witt Thomas Harris Productions. During 1990 Unocal and Mechanics National Bank will celebrate important corporate anniversaries at the museum. Unocal reaches its first century mark and Mechanics will complete forty-five years in operation with gala parties in our handsome museum.

STARRING: THE NATURAL HISTORY MUSEUM. The museum's facilities are also in demand by local movie and television production companies (see TERRA, November/December 1987). It recently appeared in *Bad Influence, Little White Lies, Pretty Woman,* "Beauty and the Beast," and "The Bold and the Beautiful." In addition to playing itself, the museum has been cast as an Italian museum, the San Francisco Opera, and the American Museum of Natural History in New York.

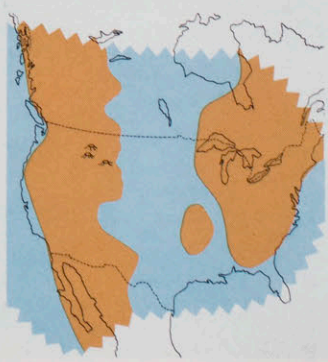
ANNOUNCEMENT

INDEX TO TERRA VOLUME 27 AVAILABLE. A comprehensive index to Volume 27 of TERRA is now available through the Natural History Museum's Publications Office. Please contact the office at the Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007, if you would like to receive a copy. Indexes to volumes 22 to 26 are also available.

ERRATA. The text of "California Ranchos: An Enduring Legacy" by Iris H.W. Engstrand, which appeared in the Winter 1989 issue of TERRA, was reprinted with permission from the *Journal of the West,* XXVII, no. 3, July 1988, copyright 1988 by the Journal of the West, Inc. No additional copies may be made without the express written consent of the publisher. An expanded version of this issue of *Journal of the West* is available as *Spanish & Mexican Land Grants and the Law* (Manhattan, KS: Sunflower University Press, 1988, $12 postage paid). Dr. Engstrand is a Research Associate in the History Division General Americana section of the Natural History Museum.

On page 46 of "Leviathan Amour," (TERRA, Winter 1989) some species of baleen whales, such as the blue, finback, and minke whales, are described as monogamous. Although there are no behavioral data, some researchers suggest that these species are probably slightly polygynous. They note that true monogamy in mammals is rare, usually only evolving in species where both parents are needed to care for the young. This is not the case with baleen whales.

The Late Cretaceous land and the sea areas of the map on page 27 of the Winter 1989 issue of TERRA were reversed. They should appear as on the reproduction of the map on this page.



MUSEUM TRAVEL PROGRAM

©INTERNATIONAL EXPEDITIONS

Australia – Nature's Best Kept Secret

East Africa
June 21–July 7, 1990
Trek through the major reserves of Kenya – Samburu, Masai Mara, and Amboseli – and the best parks in Tanzania – Ngorongoro Crater, Serengeti, and Lake Manyara – on this wildlife safari led by Jim Olson, Chief of the museum's Exhibits Division. Enjoy a behind-the-scenes tour at the Nairobi Museum and a special visit to Olduvai Gorge. Share tales of lion, black rhino, wildebeest, giraffe, and elephant sightings over the campfire at Fig Tree Camp in Masai Mara, where the night is alive with the sounds of the wild.
$5,195 including airfare

Australia: Nature's Best-Kept Secret
July 21–August 11, 1990
Australia is home to a unique and diverse flora and fauna. Due to its total isolation, many distinct forms of plant and animal life have evolved here and nowhere else. Visit Lone Pine Koala Sanctuary, where koalas are bred and introduced into the wild. Hike through Lamington National Park, one of the best regions for sighting endemic birds in all Australia. View aboriginal rock art at Obiri Rock, Nourlangie Rock, and Ayer's Rock. Reef walk, snorkle, or dive on Heron Island, situated on the Great Barrier Reef.
$4,998 including airfare

Project Indonesian Heritage: Bali, Torajaland, and Komodo
August 7–26, 1990
Of all the earth's countries, Indonesia is often said to be the most diverse. Its 13,667 islands span the Indo-Malayan and Australian biogeographic realms, making the wildlife dramatically diverse. Tour idyllic Bali and snorkle over the coral reefs of Satonda, Kabaena, Tukanbesi, and Lucipara. Meet the Toraja people of Sulawesi and shop for some of the finest ikats in Indonesia on Savu and Sumba. Venture into the realm of the prehistoric dragon of Komodo Island. Your home will be the *World Discoverer,* an expedition vessel ideally suited to explore this country of islands.
$6,165 to $8,865 including airfare

Santa Fe Indian Market and Pueblo Indian Feast Days
August 10–20, 1990
Indian, Spanish, and Anglo cultures, past and future, tradition and innovation–for the most part these elements remain unmerged, but firmly linked, in Santa Fe. Investigate the wealth of museums, archaelogical sites, national monuments, pueblos, and galleries encompassed by Albuquerque, Taos, and Sante Fe with anthropologist Kendra Bowers. Share feast-day activities in native homes and experience the world-famous Sante Fe Indian Market, where hundreds of artisans display and sell their wares.
$1,708 including airfare

Peru
October 21–November 4, 1990
The majesty of Machu Picchu, the beauty of the snow-covered Andes, the colorfully clad Indians, and the national congeniality of the Peruvian people touch the senses and enrich the soul. Meet Dr. Walter Alva, discoverer of Lord Sipan's mausoleum, and famed adventurer Thor Heyerdahl at his excavation at Tucume. Journey to Colca Canyon in the Arequipa region, where there is a chance to see the legendary Andean Condors.
$3,195 including airfare

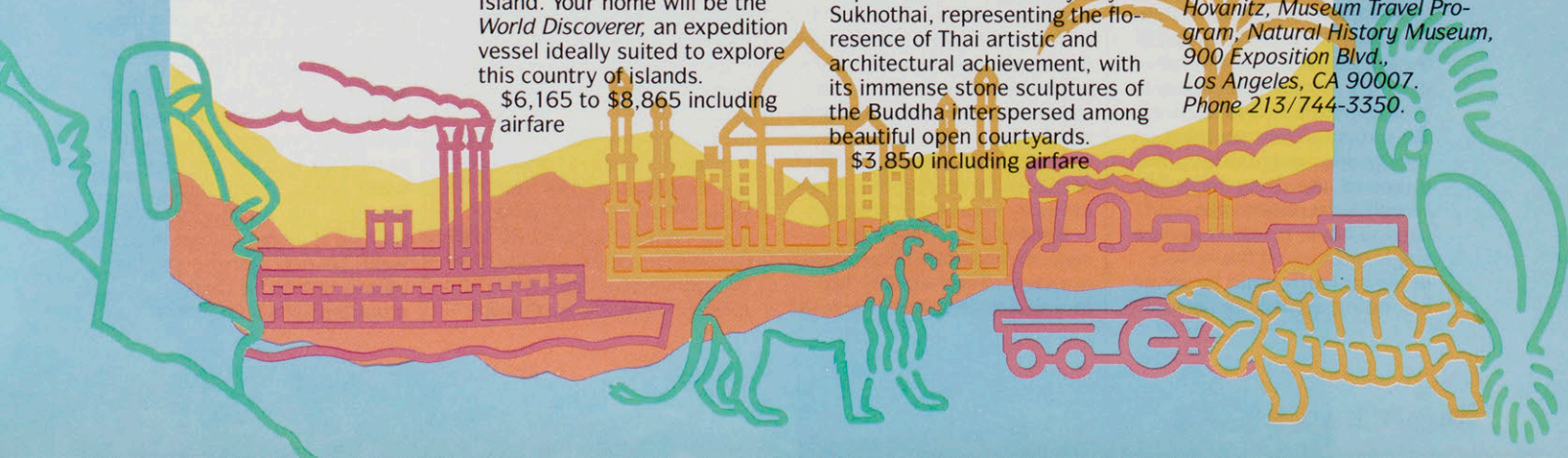
Singapore and Thailand
November 3–19, 1990
Marvel at Singapore's many cultures, then travel to Bangkok for an overview of Thailand, past and present. Shop at the colorful native market of Phitanhthai before continuing to Chaing Mai, "flower of the north," typified by impressive mountain scenery, ancient temples, colorful hill tribes, and an amazing array of handicrafts. Visit an elephant training camp in a teak forest. Explore the 12th-century city of Sukhothai, representing the florescence of Thai artistic and architectural achievement, with its immense stone sculptures of the Buddha interspersed among beautiful open courtyards.
$3,850 including airfare

Treasures of Pre-Columbian Mexico
December 4–18, 1990
Beginning with the ancient metropolis of Teotihuacan, observe and learn about the Olmecs, Toltecs, Teotihuacanos, the Totonacs, the Mixtecs, Zapotecs, and the Aztecs, covering a period of more than 3,000 years of human development with archaeologist Richard Hansen as your guide. Journey through central Mexico's scenic highlands to the state of Veracruz and the spectuacular ruins at El Tajin. View the Aztec and Olmec sculpure in Jalapa and shop for wonderful handicrafts in Oaxaca.
$2,741 including airfare

In the Footsteps of Scott and Shackleton
February 2–March 3, 1991
Set your sights on Ross Island in McMurdo Sound, as far south as any ship can possibly venture, and retrace the footsteps of early Antarctic explorers aboard the expedition ship, *World Discoverer.* Sailing from Port Bluff, New Zealand, you will explore remote islands of the Southern Ocean via Zodiac and visit the huts of the first explorers, preserved almost a hundred years, as well as modern Antarctic research stations.
From $12,910 plus airfare

Total Solar Eclipse in Baja, California
July 9–14, 1991
Astronomers and meteorologists agree: Los Cabos, at the tip of Baja California, is the ideal location to view the July 11, 1991, solar eclipse. The sun will be in total eclipse for nearly seven minutes. Our tour also allows ample time to explore the fascinating botany, geology, and marine life of Baja.
$995 plus airfare

For complete information about trips listed, please contact Karen Hovanitz, Museum Travel Program, Natural History Museum, 900 Exposition Blvd., Los Angeles, CA 90007. Phone 213/744-3350.



Book Reviews

WONDERFUL LIFE: THE BURGESS SHALE AND THE NATURE OF HISTORY
by Stephen Jay Gould.
W.W. Norton, $19.95

Every now and then a book appears that steps back from the minutiae of scientific advancement and weaves the multifarious threads into a coherent fabric that revises our view of the world. Stephen Jay Goulds' *Wonderful Life* is such a book. The framework on which Gould builds is a synopsis of the fauna of the Burgess Shale, a 530-million-year-old outcropping of rock in Yoho National Park, British Columbia. Discovered in 1909 by Charles Doolittle Walcott, Secretary of the Smithsonian Institution, the shale is remarkable for its extraordinary preservation of soft-bodied animals. The Burgess Shale is a window into the Middle Cambrian, a time only shortly after the enigmatic "Cambrian explosion," which saw the emergence of most of the major lineages of multicellular life that populate our modern world.

Gould's book is not simply an account of the bizarre paleobiology of those distant times. Indeed, Gould discusses at length the human history of the Burgess saga, beginning with Walcott's misinterpretation of his fossils. Walcott saw each Burgess animal as a primitive precursor in the long road of evolutionary diversification and increasing sophistication. This view has recently been overturned—not overnight, but through a long gestation beginning in the early 1970s. The Burgess Shale organisms represent some fifteen to twenty phyla, half as many phyla as now account for all the animals on Earth. At least eight phyla, and several more yet to be described, have no living representatives. Of some twenty-five fundamentally different arthropod body plans represented in the Burgess fauna, only four gave rise to successful lineages (and only three survived until the present). The remaining twenty-one lineages are unknown after Burgess times. Here lies the importance of Gould's book, summed up in a single question: if the history of life on Earth could be rerun, beginning again in Burgess times, would the results be anything like those we see around us today? Traditional evolutionary thinking would conclude the answer to be yes, arguing that the organisms that emerged from the Cambrian potpourri and gave rise to successful evolutionary lineages were those endowed with superior designs. These organisms with body plans less well engineered were the ones that perished and would be the ones to do so again if history were replayed. Gould argues persuasively for an alternative view—that an objective visitor to the Cambrian oceans probably could not have predicted the winner in the great lottery of life. The organisms of the Burgess Shale whose lineages were extinguished in subsequent history were neither structurally, nor in so far as we can judge, genetically inferior to those organisms destined to survive. Gould argues that the survivors were simply the lucky ones. That is not to say that individual extinctions were truly random—the driving forces of extinction were climate change, global geotectonics, perhaps even extraterrestrial impacts—but the proximal effects of these events were unpredictable and the survivors were simply more fortunate in some combination of unrelated adaptation, ecology, or biogeography.

Gould argues that the modern world is the result of half a billion years of such unpredictable contingencies, and whereas in retrospect the results are eminently logical, in prospect the results are infinitesimally improbable. Wind back the clock of history to the Middle Cambrian and replay life's great saga and we would create a world full of extraordinary creatures, but without dinosaurs or bats or *Homo sapiens*.

If Gould is right, and the evidence certainly favors him, the implications are fundamentally important. Humanity becomes not the logical pinnacle of an inevitable evolutionary ratchet of increasing intelligence, but a uniquely improbable accident.

Wonderful Life represents such an important revision of our view of evolutionary history that it deserves to be read for content alone. The fact that it is superbly well written is an added bonus and establishes the book as a major work.

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THE TWENTIETH-CENTURY WEST: HISTORICAL INTERPRETATIONS
edited by Gerald D. Nash and Richard W. Etulain.
University of New Mexico Press, $17.50 (paper).

This anthology reflects an awakening by Western American historians to the dynamic history of the more recent West. The thirteen essays, sandwiched between an insightful prologue written by Richard W. Etulain and an astute epilogue by Gerald D. Nash, seek to offer a guide for those wishing to study the twentieth-century West further.

Asking rhetorically—"What happened to the American West after the frontier was no more?"—Etulain prods scholars to look beyond the traditional 1890 terminal date for Western studies. In the opening essay Walter Nugent observes that the rate of growth in the western states between 1890 and 1980 was more than twice that of the country as a whole. This alone ought to be enough to urge a closer examination of the region.

While it is impossible to assess thirteen essays fully in a brief review, let me attempt to highlight three likely to be of particular interest to southern Californians: Carl Abbott's consideration of Western cities, Ricardo Romo's look at Mexican-Americans in the West, and Donald J. Pisani's historiographical coverage of Western water history.

Abbott scrutinizes urban growth in the western states—focusing especially upon the years since 1940. He concludes that by 1980 the West was well on its way to becoming "*the* urban region of the West," and a profound image change from the supposed cowboy and Indian West envisioned by many not too long ago. By 1980 the Los Angeles-Anaheim metropolitan center formed the nation's second largest urban complex, the Bay Area the fifth, Houston-Galveston eighth, and Dallas-Ft. Worth ninth. In fact, fourteen of the twenty fastest growing metropolitan areas were in the western United States.

Yet, not all Westerners share equally in the phenomenal growth. Among those left on the fringes socially, politically, and economically, and generally ignored by historians as well, are the Mexican-Americans. Early in this century thousands of unskilled Mexicans workers were lured northward by the promise of better wages accompanying the dam construction projects that swept the West as part of the Newlands Reclamation Act of 1902. By World War I unskilled Mexican workers constituted the larger share of unskilled day laborers in Los Angeles and other western urban centers. Naturally, unskilled translated into lower wages and social position. Romo asserts that the federal government inadvertently encouraged the mass migrations from Mexico with the tempting higher wages of projects such as dam construction and the like. Current crisis-level immigration, which creates border control problems for the United States and drains Mexico of, perhaps, the most ambitious segment of its society, can be traced directly to these early twentieth-century policies.

Finally, Donald Pisani's treatment of "Neglected Aspects of Water History in the Twentieth-Century" proves enlightening. All southern Californians *should* have a strong interest in water history since without water Los Angeles becomes nothing more than a desert! Pisani reminds us of the Los Angeles-Owens Valley controversy of an earlier generation. Whether seen as a success story of wise vision as one historian has interpreted it or the product of urban villainy as another sees it, the controversy offers much wisdom for late twentieth-century Californians as we look to solve our own water needs. Pisani then launches into a historiographical look at recent studies of water history. Taking some historians to task for their crusading attack on federal

water policies and apparent yearnings for simpler days and ways, Pisani offers readers a sound treatment of what has been written to date. Unfortunately, Pisani's diatribe distracts from an otherwise superb essay.

Anyone, from lay reader to professional historian, should find much worthwhile information in *The Twentieth Century West*. The bibliography alone is well worth the purchase price. Besides those topics treated in this review, essays on women in the West, Indians, environmental history, the lumber industry, politics, literature and art are also among those found in the anthology. As Gerald Nash notes in his concluding essay, it is time to develop a "clearer image of the West and what it has become in the last one hundred years."

M. Guy Bishop
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A PICTORIAL HISTORY OF THE JAPANESE IN HAWAII, 1885-1924, by Franklin Odo and Kuzuko Sinoto, Bishop Museum Press, distributed by the University of New Mexico Press.

A PHOTOGRAPHER IN THE KINGDOM: CHRISTIAN J. HEDEMANN'S EARLY IMAGES OF HAWAII, by Lynn Ann Davis with Newlson Foster, Bishop Museum Press, distributed by the University of New Mexico Press.

For those interested in Hawaii or Japanese overseas settlement, *A Pictorial History of the Japanese in Hawaii* is an excellent choice. For nearly a century the Japanese ethnic population of Hawaii has been numerically dominant, challenged only in the past decade or so by a mainland influx. In a sense, the history of the Hawaiian Japanese since 1890 is the history of Hawaii.

The authors have selected various topics for discussion, such as the labor movement, life on plantations, plantation work, Japanese schools, newspapers, and businesses. But the photos tell the story, accompanied by captions that supply much information. Over 350 images are in the book, several of them full-page. Admittedly, many are from secondary sources, photos copied from old Japanese books, but the quality of the photos is surprisingly good. A large number of documents in Japanese are reproduced in this fashion, which will be of more interest to those who read Japanese, perhaps, but the captions explain some of their content. Pictorial histories often fall flat because the photos are somehow irrelevant to the history that is attempted. This is not so with this book.

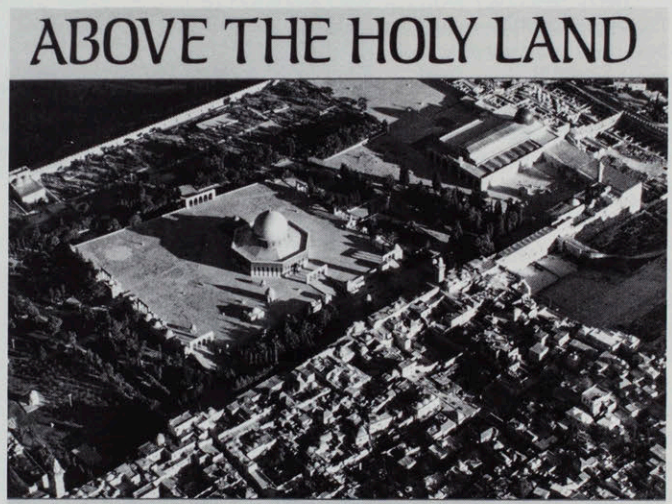
About twenty of the full-page photos are most interesting for their content as well as for their composition. We are treated also to a large number of the inevitable groups of people lined up for organizational photographs, less interesting than the other images offered. Rows of schoolchildren look pretty much the same everywhere. But this is merely offered as an observation, rather than a criticism. These are the photos that survive best, and they are as a result the sole memoirs of organizations and schools.

C. J. Hedemann and his wife Meta arrived in Hawaii from Denmark in 1878. He was to be the engineer for the sugar mill at Hana, Maui. He began to photograph Hana and its surroundings about 1880 as an amateur photographer, using as subjects not only his family but also his neighbors, who were native Hawaiians, for the most part. Aspects of Hawaii not often seen are included in his photographs. For example, the Honolulu Iron Works is well represented. As might be expected, some Danish families of Hawaii are also included.

Even the family photographs are more interesting than they might be, likely owing to judicious choices on the part of the authors. There are the stock scenic views, such as the view of Diamond Head from the Punchbowl or the Nu'uanu Pali. Home interiors of the 1880s and 1890s, children at play, and a variety of other aspects of Hawaiian life not always seen make the photo selections something other than pedestrian. When we see Iolani Palace it is at the time of the promulgation of the Constitution of 1893. Good photos collected by Hedemann from other photographers' efforts do have often-seen aspects, such as the one for the lei-sellers, a turn-of-the-century stock photo, or the Hawaiian grass house. The difference here is the quality of the photo and the reproduction.

Accompanying the photos is a detailed chronicle of the Hedemanns' lives and of the elements surrounding them in Hawaii, from 1878 into the 1920s. It is a quite readable text, and interweaves Hawaiian events as they affected residents such as the Hedemanns.

William Mason
General Americana Section
Division of History



THE HOLY LAND: ISRAEL FROM THE AIR by Baron Wolman. Chronicle Books, $35.

At first glance, this is merely a book of aerial photographs of the land of Israel—a coffeetable book. But it is also of interest to the archaeologist because in many of these clear color pictures, we are able to look at historical sites from a different angle and thereby obtain a better understanding of their nature and importance in their natural setting.

For example, Jerusalem is a crowded, cluttered hodgepodge of buildings, built up over many centuries, with a spider web of narrow streets themselves often covered and hidden by more buildings. Typical of most Middle Eastern cities, one gets the full flavor of the cramped conditions of ancient cities confined within their defensive walls. Only the holy precinct and the Temple Mount are uncrowded. The Citadel, partly built by King Herod, can also be seen as a fortress of massive strength.

At Antipatris, we see a Turkish fort built on the ruins of a Crusader castle. Carefully laid-out excavations further reveal remains of a palace from the Middle Bronze Age. Other sites include Megiddo (Armageddon), Kfar Nahum (Capernaum), Massada, Avdat, and Herodion, near Bethlehem, where Herod is buried.

Two more sites should be mentioned: first, at Belvoir, we have a well-preserved Crusader fortress with a double baily (a fortress within a fortress) perched on a mountain top that, despite its impregnability, fell to the Saracens. Second, a view of a lush palm grove in Jericho reminds us that this place was known as the "City of Palms" and was a resort city in both Roman and Arab times.

Finally, the pictures of modern Israel are interesting, and here one can see both planned and unplanned development and its effects on the landscape. These new additions will be the domain of future archaeologists.

Jay Bisno
Anthropology Section

Santa Fe Railway Depot

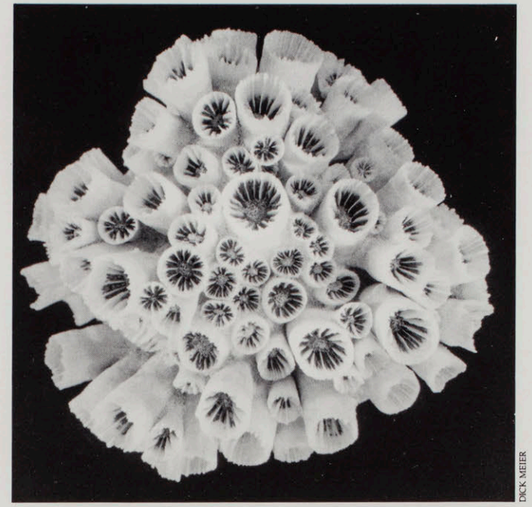
The Santa Fe Railway entered Los Angeles in the late 1880s. In 1887 fire destroyed the line's original station, so in 1891 a new beginning was made on Santa Fe Avenue between First and Second Street. The station's formal opening took place before an excited throng on July 29, 1893. Senator Stephen White delivered eloquent remarks to commemorate the event.

Frank Levet, a 27-year old draftsman in the railroad's engineering department, designed a structure combining Turkish and Moorish traditions. This photograph from the early twentieth century offers a clear indication of the depot's architectural charm. Popularly known as *La Grande*, the building stood along the west bank of the Los Angeles River. The station boasted an interior trimmed in Oregon pine and California redwood, with separate lunchrooms and waiting facilities for ladies and gentlemen. The motto *East or West, Santa Fe Is Best* was carved in sandstone in each waiting room.

During the early twentieth century the station was a popular site for moviemakers who temporarily changed its name to "Warm Springs" or other fictional towns. The opening of the new Union Passenger Terminal in 1939 brought the retirement of this fine old station, which was razed in 1946.

GENERAL PHOTO FILE 2994

***Focus on the West: Images from the Seaver Center** is a* TERRA *feature that presents the photographic highlights of the museum's Seaver Center for Western History Research. The Seaver Center is rich in photographs and other materials relating to the history of the American West.*



DICK MEIER

A modern tropical coral collected from Mexican waters at Land's End, Baja California Sur, where the temperature is sometimes cold enough for wet suits.

Q: My biology teacher says that since all living coral reefs occur only in very warm seas, all fossil coral reefs must indicate similar water temperatures for the times when they were alive. Is he right?

A: Partly, according to curator and coral paleontologist Dr. Edward Wilson, who is delighted that your teacher has introduced you to the Principle of Uniformitarianism (the present is the key to the past). An expert should identify the kind of coral forming a fossil coral reef before any assumption is made about paleotemperatures—that is, temperatures in prehistoric times.

Modern corals of the reef-forming group belong to the Order Scleractinia and are restricted to relatively shallow waters of the tropics and semi-tropics. These are the corals popularly associated with coral reefs. They generally grow best in water temperatures of 25 to 30 degrees C (76 to 86 degrees F), certainly comfortably warm.

Fossil reef-forming corals generally suggest similar paleotemperatures, as your teacher has stated. However, a modern coral reef in a bay on the southern part of the Baja California peninsula was recorded as living in very chilly waters of 11 degrees C (52 degrees F) in June 1979, which must be about as cold as the corals can stand without dying. Another group of scleractinian corals that are not reef forming lives in depths as great as 6,000 meters (19,700 feet) and in water temperatures as low as 0.5 degrees C (33 degrees F) and forms reeflike mounds in places. Fossil mounds of this kind do not suggest warm water. Two other orders of corals (Rugosa, Tabulata) assisted in the formation of some reefs, but both orders are long extinct, so assumptions about their paleotemperature environments are made without the assistance of close modern relatives for comparison.

The museum's curators are often asked natural history or historical questions or to identify artifacts and specimens that people have found, purchased, or inherited and animals, plants, minerals, and fossils that they have encountered in their yards or at the beach or on a hike. "Housecalls" is a feature of* TERRA *in which the museum's curatorial staff discusses interesting questions that the museum's members and the general public have frequently asked them.

SHARKS

FACT AND FANTASY

P·O·S·T·E·R

The central valley of California was once covered by the Pacific Ocean. The Natural History Museum's own scientific illustrator, Michael Meeker, has beautifully portrayed this environment in his painting *Graveyard of the Deep.* He depicts some of the marine mammals and more than 28 species of sharks that lived here between 13 and 15 million years ago. Their fossil remains have been uncovered at Sharktooth Hill near Bakersfield, California. Meeker's painting has been reproduced as a handsome full-color poster. $8.95. To order, call 213/744-3434.

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